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(54) Keyboard musical instrument having hammer stopper exactly position at blocking position

(57) A keyboard musical instrument selectively enters into an acoustic sound mode for generating acoustic piano tones and an electronic sound mode for generating electronic sounds instead of the acoustic piano tones, and a stopper (310) is changed between a free position (FP) and a blocking position (BP) by an actuator controlled through detection with photo-interrupters, thereby eliminating aged deterioration from the position control between the free position and the blocking position.

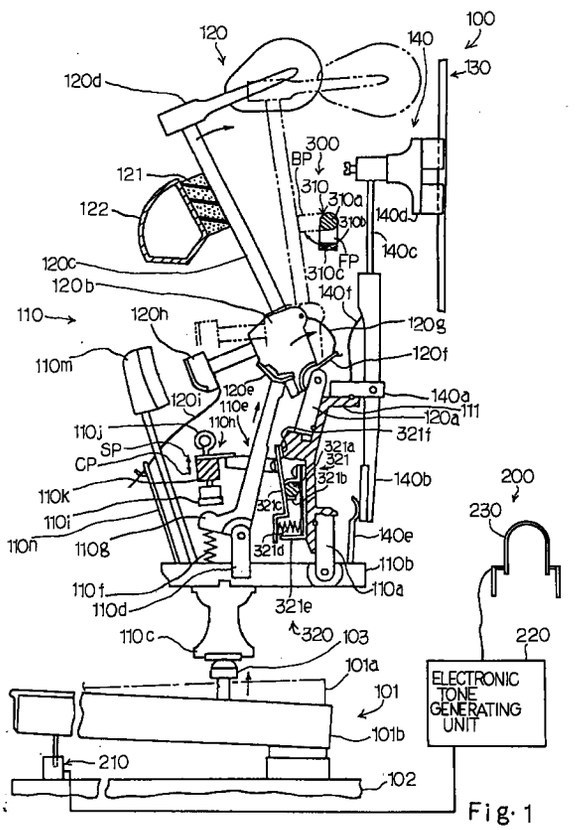

Fig. 1

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Description

FIELD OF THE INVENTION

This invention relates to a keyboard musical instrument and, more particularly, to a keyboard musical instrument having a hammer stopper exactly positioned at a blocking position.

DESCRIPTION OF THE RELATED ART

A typical example of the keyboard musical instrument is disclosed in U.S. Serial No. 08/073,092 claiming the priority right on the basis of Japanese Patent Application Nos. 4-174813, 4-207352, 4-299234 and 5-31420, and the U.S. Patent Application resulted in U.S Patent No. 5,374,775.

The prior art keyboard musical instrument largely comprises an acoustic piano, an electronic sound generating system and a controlling system. When a player selects the acoustic tones, the controlling system changes a hammer stopper to a free position, i.e., outside of the trajectories of the hammers incorporated in the acoustic piano, and the hammers strike the strings so as to generate the acoustic tones. On the other hand, if the player selects the electronic sounds, the controlling system changes the hammer stopper to a blocking position on the trajectories of the hammers, and the hammers rebound on the hammer stopper before strikes at the strings. The electronic sound generating system monitors the keyboard, and generates electronic sounds corresponding to the acoustic tones to be generated.

A typical example of the hammer stopper is implemented by a rotatable shaft member provided with cushions and laterally extending between the strings and the hammer shanks at the home positions. The cushions project from the outer surface of the rotatable shaft member, and are opposed to the hammer shanks in the blocking position. On the other hand, while the hammer stopper is staying in the free position, the outer surface of the rotatable shaft member is opposed to the hammer shank, and the hammers strike the strings without the interruption of the hammer stopper. Thus, the hammer stopper is changed between the free position and the blocking position depending upon the selection of the player.

The hammer stopper is driven for rotation by means of a suitable driver unit. The driver unit is broken down into an electric motor associated with a controller and a link mechanism. The link mechanism is economical rather than the electronic motor system, and is, by way of example, disclosed in U.S. Patent No. 5,386,083.

A typical example of the link mechanism includes a flexible wire extending between the complicated mechanisms of the acoustic piano, and is terminated at a foot pedal or a hand grip. When the player manipulates the foot pedal or the hand grip, the flexible wire transfers the motion of the foot pedal/hand grip to the rotatable shaft member, and changes the hammer stopper between the free position and the blocking position.

The prior art keyboard musical instrument thus arranged encounters a problem in that the hammer stopper varies the blocking position. When the hammer stopper does not reach the blocking position, the hammer stopper can not interrupt the hammers before the strikes at the strings, and the hammers softly strike the strings upon the rebound on the hammer stopper. As a result, the acoustic sounds are unintentionally generated, and the player feels the unintentional acoustic sounds noisy.

SUMMARY OF THE INVENTION

It is therefore an important object of the present invention to provide a keyboard musical instrument which is free from the unintentional acoustic sounds.

The present inventors contemplated the problem inherent in the prior art keyboard musical instrument, and noticed that a plastic deformation had taken place in a cushion member associated with the foot through repetition of the manipulation of the foot pedal. The present inventors further noticed that the flexible wire had been elongated due to the repetition of the manipulation of the foot pedal/hand grip. Nevertheless, the cushion member was indispensable for eliminating a noise from the change-over action, and the flexible wire could not be replaced with a rigid links because the available space was too narrow. For this reason, the present inventor concluded that an electric motor was better rather than the link mechanism in view of a maintenance-free product.

Although the usage of electric motor had been proposed in the aforesaid U.S. Patent Application No. 08/073,092, i.e., U.S. Patent No. 5,374,775, the specification did not teach an effective positioning control technique.

To accomplish the object, the present invention proposes to detect a position of a hammer stopper in a non-contact manner.

In accordance with the present invention, there is provided a keyboard musical instrument having at least an acoustic sound mode for generating acoustic sounds and an electronic sound mode for generating electronic sounds, comprising: an acoustic piano including a keyboard having a plurality of turnable keys respectively assigned notes of a scale and selectively depressed by a player in both of the acoustic sound mode and the electronic sound mode, a plurality of string means for generating the acoustic sounds in the acoustic sound mode, a plurality of hammer assemblies respectively associated with the plurality of string means and driven for rotation for striking the plurality of string means in the acoustic sound mode, and a plurality of key action mechanisms functionally connected between the plurality of turnable keys and the plurality of hammer assemblies, respectively, and having respective jacks escaping from the plurality of hammer assemblies when the plurality of keys are depressed by the player; an electronic sound

generating system for generating the electronic sounds having the notes corresponding to the keys depressed by the player in the electronic sound mode; and a silent system including a hammer stopper having an interrupter changed between a free position and a blocking position, the interrupter entering into the free position in the acoustic sound mode so as to allow the plurality of hammer assemblies to strike the plurality of string means, the interrupter entering into the blocking position in the electronic sound mode so as to cause the plurality of hammer assemblies to rebound thereon before a strike at the plurality of string means, a first actuator means responsive to an instruction of the player so as to change the hammer stopper between the free position and the blocking position, and a first position controller having a first non-contact sensor operative to detect the interrupter upon an entry into the free position and a second non-contact sensor for detecting the interrupter upon an entry into the blocking position, the first actuator means stopping the interrupter when the first non-contact sensor and the second non-contact sensor report the entry into the free position and the entry into the blocking position.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the keyboard musical instrument according to the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a side view showing the structure of a keyboard musical instrument according to the present invention;

Fig. 2 is a perspective view showing an essential part of a silent system incorporated in the keyboard musical instrument according to the present invention;

Figs. 3A and 3B are views showing detections by photo-interrupters incorporated in the silent system;

Figs. 4A and 4B are views showing irregular positions of a shutter plate;

Fig. 5 is a partially cut-away side view showing an essential structure of a keyboard musical instrument according to the present invention;

Fig. 6 is a partially cut-away side view showing a lifter incorporated in the keyboard musical instrument;

Fig. 7 is a plan view showing the lifter;

Fig. 8 is a perspective view showing the structure of a gap regulator incorporated in the keyboard musical instrument;

Fig. 9 is a disassembled perspective view showing the structure of a shank stopper incorporated in the keyboard musical instrument;

Fig. 10 is a perspective view showing a driving mechanism for the shank stopper;

Fig. 11 is a perspective view showing a gap regulator incorporated in yet another keyboard musical instrument according to the present invention;

Fig. 12 is a cross sectional view showing a slider of the gap regulator;

Fig. 13 is a side view showing a regulating button controller incorporated in still another keyboard musical instrument according to the present invention;

Fig. 14 is a cross sectional view showing an auxiliary regulating button incorporated in the regulating button controller;

Fig. 15 is a side view showing a flexible coupling between an electric motor unit and a shaft member;

Fig. 16 is a perspective view showing another position controller;

Figs. 17A to 17D are views showing relative relation between a shutter plate and photo-interrupters of the position controllers; and

Fig. 18 is a view showing yet another position controller.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Referring first to figure 1 of the drawings, a keyboard musical instrument embodying the present invention largely comprises an upright piano 100, an electronic sound system 200 and a silent system 300. In the following description, word "front" means a position closer to a player sitting before the uptight piano for playing it, and, accordingly, a "fore-and-aft direction" extends between the front and the rear. On the other hand, a "lateral direction" is in perpendicular to the fore-and-aft direction. Terms "clockwise" and "counter clockwise" are determined on a sheet where a reference figure is illustrated.

The upright piano 100 comprises a keyboard 101, and black keys 101a and white keys 101b form the keyboard 101. Notes of a scale are respectively assigned to the black and white keys 101a and 101b, and the black and white keys 101a and 101b are turnable with respect to a key bed 102. When a player depresses the key 101a/101b, the depressed key 101a/101b turns in the counter clockwise direction, and is moved from a rest position to an end position. A capstan screw 103 is implanted into a rear portion of each of the black and white keys 101a/101b.

The upright piano 100 further comprises a plurality of key action mechanisms 110, a plurality of hammer assemblies 120, a plurality of strings 130 and a plurality of damper assemblies 140.

The plurality of key action mechanisms 110 are respectively associated with the black and white keys 101a/101b, and the plurality of key action mechanisms 110 are similar in structure to one another. The key action mechanisms 110 are supported by a center rail 111, and

the center rail 111 is connected to action brackets (not shown) mounted on the key bed 102.

The key action mechanism 110 includes a whippen flange 110a fixed to the rear surface of the center rail 111, whippen 110b turnably supported by the whippen flange 110a and a whippen heel 110c attached to the bottom surface of the whippen 110b. The capstan screw 103 is held in contact with the whippen heel 110c, and the capstan screw 103 pushes the whippen heel 110c during the movement of the key 101a/101b from the rest position to the end position.

The key action mechanism 110 further includes a jack flange 110d upwardly projecting from a central portion of the whippen 110b, a jack 110e turnably connected to the jack flange 110d and a jack spring 110f provided between the toe 110g of the jack 110e and the whippen 110b. The jack spring 110f urges the jack 110e to turn in the clockwise direction.

The key action mechanism 110 further includes a regulating mechanism 110h, and the regulating mechanism 110h has a regulating button 110i opposed to the toe 110g, a regulating screw 110j screwed through a regulating rail 110k into the regulating button 110i. The regulating screw 110j is screwed into and out of the regulating rail 110k, and changes a gap between the regulating button 110i and the toe 110g.

The key action mechanism 110 further includes a back check 110m upwardly projecting form a front portion of the whippen 110b and a bridle wire 110n also projecting from the front end portion of the whippen 110b. The back check 110m and the bridle wire 110n will be hereinlater described in connection with the hammer assembly 120.

The hammer assemblies 120 are respectively associated with the plurality of key action mechanisms 110, and are similar in structure to one another. When the black and white keys 101a/101b are selectively depressed by the player, the associated key action mechanisms 110 rotate the hammer assemblies 120 in the clockwise direction, and strike the associated strings 130.

The hammer assembly 120 includes a butt flange 120a attached to a front surface of the center rail 111, a hammer butt 120b rotatably connected to the butt flange 120a, a hammer shank 120c projecting from the hammer butt 120b and a hammer head 120d attached to the hammer shank 120c. A butt skin 120e is attached to a lower surface of the hammer butt 120b, and the top end of the jack 110e is held in contact with the butt skin 120e while the associated key 101a/101b is staying in the rest position.

The hammer assembly 120 further includes a butt spring cord 120f connected to the butt flange 120a and a butt spring 120g connected between the butt spring cord 120f and the hammer butt 120b. The butt spring 120g urges the hammer butt 120b and, accordingly, the hammer shank 120c in the counter clockwise direction, and the hammer shank 120c is softly pressed against a hammer rail cloth 121 attached to a hammer rail 122. The hammer rail cloth 121 defines a home position for the hammer assembly 120.

The hammer assembly 120 further includes a catcher 120h projecting from the hammer butt 120b and a bridle tape 120i provided between the catcher 120h and the bridle wire 110n. As described hereinbefore, when the player depresses the key 101a/101b, the associated key action mechanism 110 rotates the hammer assembly 120 in the clockwise direction, and the hammer assembly 120 rebounds on the string 130. The catcher 120h is brought into contact with the back check 110m, and the back check 110m and the bridle tape 120i make the hammer assembly 120 quickly return to the home position.

The plurality of strings 130 are respectively associated with the black and white keys 101a/101b, and vibrate upon impacts with the hammer assemblies 120. When the hammer assemblies 120 strike the associated strings 130, the strings 130 vibrates at respective fundamental frequencies, and generate the acoustic sounds having the notes identical with the notes assigned to the associated black and white keys 101a/101b.

The plurality of damper mechanisms 140 are respectively associated with the key action mechanisms 110 and, accordingly, the black and white keys 101a/101b, and are similar in arrangement to one another. The damper assemblies 140 are held in contact with the strings 130, respectively, and leave the strings 130 in response to the key motions.

Namely, the damper mechanism 140 includes a damper lever flange 140a attached to the center rail 111, a damper lever 140b rotatably supported by the damper lever flange 140a, a damper wire 140c projecting from the damper lever 140b, a damper head 140d attached to the damper wire 140c, a damper spoon 140e implanted into the rear portion of the whippen 110b and a damper spring 140f provided between the damper lever flange 140a and the damper lever 140b. While the key 101a/101b is staying in the rest position, the damper spring 140f urges the damper lever 140b in the clockwise direction, and the damper head 140d is held in contact with the string 130. The damper head 140d prohibits the string 130 from the vibration. If the player depresses the key 101a/101b, the capstan screw 103 pushes up the whippen heel 110c, and the whippen 110b is rotated in the clockwise direction around the whippen flange 110a. The damper spoon 140e declines, and pushes the lower portion of the damper lever 140b. As a result, the damper lever 140b is rotated in the counter clockwise direction around the damper lever flange 140a, and the damper head 140d leaves the string 130. When the player releases the key 101a/101b, the whippen returns to the initial position, and the damper lever spring 140f urges the damper lever so that the damper head 140d is brought into contact with the string 130 again.

Though not shown in figure 1, the upright piano further comprises pedal mechanisms, i.e., a damper pedal and a soft pedal. The pedal mechanisms are similar to

those of a standard upright piano, and are not described hereinbefore in detail for the sake of simplicity.

As described hereinbefore, the upright piano is a standard type, and any kind of upright piano is available for the keyboard musical instrument according to the present invention.

The electronic sound system 200 comprises a plurality of key sensors 210 for monitoring the black and white keys 101a/101b, an electronic tone generating unit 220 connected to the key sensors 210 for generating an audio signal and a headphone 230 for generating electronic sounds from the audio signal.

Each of the key sensors has a plurality of photo-interrupters and a shutter plate attached to the key 101a/101b, and reports the interruptions of the light beams of the photo-interrupters.

The electronic tone generating unit 220 is similar to the sound processing unit disclosed in U.S. patent No. 5,374,775, and is not described in detail.

Hammer sensors may be installed instead of the key sensors 210.

The silent system 300 comprises a hammer stopper 310 and a regulating button controller 320, and changes the keyboard musical instrument between an acoustic sound mode and an electronic sound mode. The player performs a music through the acoustic sounds in the acoustic sound mode, and can practice a fingering on the keyboard 101 without the acoustic sounds in the electronic sound mode. While the keyboard musical instrument is in the electronic sound mode, the player can listen to the music through the headphone 230.

The hammer stopper 310 includes a rotatable shaft member 310a laterally extending between the hammer shanks 120c, a plurality of bracket members 310b attached to the rotatable shaft member 310a at intervals and a plurality of cushion members 310c respectively attached to the bracket members 310b. The cushion members 310c attached through the bracket members 310b to the rotatable shaft member 310a are similar to the hammer stopper illustrated in figure 2 of U.S. Patent 5,374,775, and no further description is incorporated hereinbelow.

When the player selects the electronic sound mode, the cushion members 310c are opposed to the hammer shanks 120c, and the hammer shanks 120c rebound on the cushion members 310c without a strike at the strings 130. This position is called as "blocking position" BP. On the other hand, while the player selects the acoustic sound mode, the cushion member 310c are downwardly directed, and the outer surface of the rotatable shaft member 310a is opposed to the hammer shanks 120c. The hammer heads 120 strike the strings without an interruption of the hammer stopper 310, and this position is called as "free position FP".

The hammer stopper 310 further comprises an electric motor unit 310d, and the electric motor unit 310d is mounded on a bracket member 310e attached to a side board 150 of the upright piano (see figure 2).

The hammer stopper 310 further comprises a position controller 310f, and the position controller 310f includes a shutter plate 310g fixed to the rotatable shaft member 310a, two photo-interrupters 310h and 310i provided on a rigid board member 310j, a control circuit 310k and a push button switch 310m. The controlling circuit 310k and the push button switch 310m are shared with the regulating button controller 320, and the push button switch 310m is provided on a manipulating switch board 310n together with other switches provided for the electronic sound system 200. The manipulating switch board 310n is, by way of example, provided on an upper front board (not shown) of the upright piano 100.

When a player depresses the push button switch 310m, the controlling circuit 310k acknowledges a change of the mode, and supplies driving current to the electric motor unit 310d, and the rotatable shaft member 310a is driven for rotation in one direction. The controlling circuit 310k makes a decision that the cushion members 310c enters one of the free position FP and the blocking position BP upon a detection of the shutter plate 310g by means of one of the photo-interrupters 310h and 310i, and stops the driving current.

If the player depresses the push button switch 310m again, the controlling circuit 310k supplies the driving current to the electric motor unit 310d, and the rotatable shaft member 310a is driven for rotation in the opposite direction. When the other of the photo-interrupters 310h and 310i detects the shutter plate 310g, the controlling circuit 310k makes the decision that the cushion members 310c enters the other of the free position FP and the blocking position BP, and the controlling circuit 310k stops the driving current.

The decisions made by the controlling circuit 310k may be realized through a software executed by a processor unit incorporated in the electronic tone generating unit 220.

The photo-detector 310h has a generally U-shaped block member 311a, optical fibers 311b and 311c open to a space formed in the generally U-shaped block member 311a and one of photo-couplers 312. The generally U-shaped block member 311a is mounted on the rigid board member 310j, and the position of the generally U-shaped block member 311a is changeable on the rigid board member 310j. The end of the optical fiber 311b is aligned with the end of the optical fiber 311c, and a light beam is radiated therebetween.

Similarly, the photo-detector 310i has a generally U-shaped block member 312a, optical fibers 312b and 312c open to a space formed in the generally U-shaped block member 312a and another photo-coupler 312. The generally U-shaped block member 312a is mounted on the rigid board member 310j, and the position of the generally U-shaped block member 312a is changeable on the rigid board member 310j. The end of the optical fiber 311b is aligned with the end of the optical fiber 311c, and a light beam is radiated between the optical fibers 312b and 312c.

The generally U-shaped block member 311a is adjusted on the rigid board member 310j in such a manner that the shutter plate 310g interrupts the light beam between the optical fibers 311b and 311c upon an entry of the cushion members 310c into the blocking position BP (see figure 3A). On the other hand, the generally U-shaped block member 312a is adjusted on the rigid board member 310j in such a manner that the shutter plate interrupts the light beam between the optical fibers 312b and 312c upon an entry of the cushion members 310c into the free position FP (see figure 3B).

In this instance, the rotatable shaft member 310a, the bracket members 310b and the cushion members 310c as a whole constitute an interrupter, and the electric motor unit 310d serves as an actuator means. The photo-interrupters 310h and 310i serve as a first non-contact sensor and a second non-contact sensor, respectively.

The regulating button controller 320 comprises a change-over mechanism 321 (see figure 1), an electric motor unit 322 and a position controller 323. The regulating button controller 320 changes the regulating button mechanisms 110h between a spaced position SP and a closed position CP. Namely, while the keyboard musical instrument is staying in the acoustic sound mode, the regulating button controller 320 maintains the regulating button mechanisms 110h in the spaced position SP, and the regulating buttons 110i are spaced from the toes 110g by standard distances of the upright piano 100.

On the other hand, if the player selects the electronic sound mode, the regulating button controller 320 changes the regulating button mechanisms 110h to the closed position CP, and the regulating buttons 110i advance toward the toes 110g. As a result, the toes 110g are brought into contact with the regulating buttons 110i earlier than the acoustic sound mode.

As shown in figure 1, the change-over mechanism 321 includes a rotatable shaft member 321a, bearing units 321b, a bracket member 321c, a liner 321d, a stopper member 321e and a cushion member 321f. The rotatable shaft member 321a laterally extends between the front surface of the center rail 111 and the jacks 110e, and is connected at one end thereof to the electric motor unit 322 (see figure 2). The bearing units 321b are attached to the front surface of the center rail 111 at intervals, and rotatably support the shaft member 321a. The bracket member 321c is fixed to the rotatable shaft member 321a, and the regulating mechanisms 110h are supported by the bracket member 321c. The spring member 321d is connected between the front surface of the center rail 111 and the lower portion of the bracket member 321c, and urges the bracket member 321c in the clockwise direction. The spring member 321d forces the regulating button mechanisms 110h to be in the spaced position SP.

While the regulating button mechanisms 110h is in the spaced position SP, the upper portion of the bracket member 321c is held in contact with the liner 321f attached to the front surface of the center rail 111. The liner 321f defines the spaced position SP.

If the regulating button mechanisms 110h is changed to the closed position CP, the lower portion of the bracket member 321c is brought into contact with the stopper 321e also fixed to the front surface of the center rail 111. The stopper 321e defines the closed position CP.

The position controller 323 includes two photo-interrupters 323a and 323b, a shutter plate 323c, the controlling circuit 310k and the push button switch 310m.

The photo-interrupter 323a has a generally U-shaped block member 323d, optical fibers 323e and 323f open to a space formed in the generally U-shaped block member 323d and yet another photo-coupler 312. The generally U-shaped block member 323d is mounted on a rigid board member 324, and the position of the generally U-shaped block member 323d is changeable on the rigid board member 324. The end of the optical fiber 323e is aligned with the end of the optical fiber 323f, and a light beam is radiated therebetween.

Similarly, the photo-detector 323b has a generally U-shaped block member 323g, optical fibers 323h and 323i open to a space formed in the generally U-shaped block member 323g and still another photo-coupler 312. The generally U-shaped block member 323g is mounted on the rigid board member 324, and the position of the generally U-shaped block member 323g is changeable on the rigid board member 324. The end of the optical fiber 323h is aligned with the end of the optical fiber 323i, and a light beam is radiated between the optical fibers 323h and 323i.

The generally U-shaped block member 323d is adjusted on the rigid board member 324 in such a manner that the shutter plate 323c interrupts the light beam between the optical fibers 311b and 311c upon an entry of the regulating button mechanisms 110h into the spaced position SP. On the other hand, the generally U-shaped block member 323g is adjusted on the rigid board member 324 in such a manner that the shutter plate 323c interrupts the light beam between the optical fibers 323h and 323i upon an entry of the regulating button mechanisms 110h into the closed position CP.

The photo-couplers 312 are connected to the controlling circuit 310k, and the controlling circuit 310k supplies and terminates the driving current as follows. When the player depresses the push button switch 310m for the electronic sound mode, the controlling circuit 310k supplies the driving current to the electric motor unit 322, and the shaft member 321a is driven for rotation in the counter clockwise direction. The bracket member 321c is also rotated in the counter clockwise direction, and the rotation is terminated at the stopper 321e. Then, the regulating button mechanisms 110h enter into the closed position CP, and the photo-interrupter 323g informs the controlling circuit 310k of the arrival at the closed position CP. The electric motor unit 322 continuously exerts the torque to the bracket member 321c and, accordingly, the regulating button mechanisms 110h during the elec-

tronic sound mode. As a result, even if the toe 110g pushes the regulating button 110i, the regulating button mechanisms 110h are maintained at the closed position CP. The controlling circuit may regulate the driving current at the closed position CP.

The player is assumed to depress the push button switch 310m again. The controlling circuit 310k changes the driving current, and the electric motor unit 322 rotates the shaft member 321a in the clockwise direction. The bracket member 321c and the regulating button mechanisms 110h are driven for rotation in the clockwise direction, and the upper portion of the bracket member 321c is brought into contact with the liner 321f. The shutter plate 323c concurrently interrupts the light beam between the optical fibers 323e and 323f, and the photo-interrupter 323a informs the controlling circuit 310k of the arrival at the spaced position SP. Then, the controlling circuit 310k terminates the driving current.

Description is hereinbelow made on a performance through the acoustic sounds. The player depresses the push button switch 310m, if necessary. The motor units 310d and 322 change or maintain the hammer stopper 310 and the regulating button controller 320 to or at the free position FP and the spaced position SP.

The player fingers on the keyboard 101 for performing a music. While the player is performing the music, the white key 101b is assumed to be depressed. The white key 101b is rotated in the counter clockwise direction, and the capstan screw 103 upwardly pushes the whippen heel 110c. The whippen 110b is rotated in the clockwise direction around the whippen flange 110a, and the jack 110e is also rotated around the whippen flange 110a. The jack 110e pushes the hammer butt 120c, and rotates the hammer butt 120c in the clockwise direction around the butt flange 120a.

While the whippen 110b is being rotated, the damper spoon 140e pushes the damper lever 140b, and rotates the damper lever 140b and the damper head 140d in the counter clockwise direction around the damper flange 140a. The damper head 140d leaves from the string 130, and allows the string 130 to vibrate.

When the toe 110g is brought into contact with the regulating button 110i, the regulating button 110i restricts the rotation of the jack 110e around the whippen flange 110a, and the jack 110e quickly turns around the jack flange 110d against the elastic force of the jack spring 110f. Then, the jack escapes from the hammer butt 120b, and the hammer head 120d rushes toward the string 130. The hammer head 120d strikes the string 130 without an interruption of the hammer stopper 310, and rebounds on the string 130. The string 130 vibrates, and generates the acoustic sound having the note assigned to the depressed white key 101b.

The hammer assembly 120 turns in the counter clockwise direction around the butt flange 120, and the back check 110m restricts the rotation of the hammer assembly 120. When the player releases the depressed white key 101b, the capstan screw 103 is spaced from the whippen heel 110c, and the whippen 110b is rotated in the counter clockwise direction around the whippen flange 110a. The hammer assembly 120 returns to the home position, and the jack spring 110f urges the jack 110e to return the position beneath the hammer butt 120c.

The rotation of the whippen 110b removes the force exerted by the damper spoon 140e from the damper lever 140b, and the damper spring 140f presses the damper head 140d against the string 130.

Thus, the black and white keys 101a and 101b sequentially actuate the key action mechanisms 110, the damper mechanisms 140 and the hammer assemblies, and the strings 130 selectively generates the acoustic sounds.

While the keyboard musical instrument is in the acoustic sound mode, the player is assumed to depress the push button switch 310m. The controlling circuit 310k checks the photo-interrupters 323a and 323b to see whether or not the shutter plates 310g and 323c interrupt the light beam of the photo-interrupter 310i and the light beam of the photo-interrupter 323a, respectively. If the answer is given affirmative, the hammer stopper 310 and the regulating button controller 320 are correctly positioned at the spaced position SP and the spaced position SP, and the controlling circuit 310k supplies the driving current to the electric motor units 310d and 322 so as to change the hammer stopper 310 and the regulating button controller 110h to the blocking position BP and the closed position CP.

However, if both photo-interrupters 310h/ 310i or 323a/ 323b bridge the light beams, the shutter plate 310g or 323c is irregularly positioned as shown in figure 4A or 4B. If a main power switch (not shown) cuts off the electric power during the rotation of the shaft member 310a or 321a, the shutter plate 310g or 323a is position at the intermediate position shown in figure 4A. On the other hand, if a person forcibly rotates the shaft member 310a or 321a, the shutter plate 310g or 323c is moved out of the regular trajectory as shown in figure 4B.

In this situation, the controlling circuit 310k causes the electric motor units 310d and 322 to rotate the shaft members 310a and 323c in the counter clockwise direction. If the shutter plate 310g or 321a is in the intermediate position, the shutter plate 310g or 321a interrupts the light beam of the photo-interrupter 310i or 323b. When the controlling circuit 310k acknowledges the free position FP, the controlling circuit 310k changes the driving current, and the electric motor unit 310d rotates the shaft member 310a so as to change the hammer stopper 310 to the blocking position BP. On the other hand, when the controlling circuit 310k acknowledges the closed position CP, the controlling circuit 310k regulates the driving current, and continuously supplies it to the electric motor unit 322.

On the other hand, if the shutter plate 310g or 323c is out of the trajectory as shown in figure 4B, the rotation in the counter clockwise direction brings the shutter plate 310g or 323c to the interruption of the light beam of the photo-interrupter 310h or 323a. The controlling circuit

310k further rotates the shaft member 310a or 321a over the distance equal to the width of the shutter plate 310g or 323c, and stops the hammer stopper 310 or the regulating button controller 320 at the blocking position or the spaced position SP.

When the controlling circuit 310k acknowledges the blocking position BP, the controlling circuit 310k does not supply the driving current to the electric motor unit 310d. However, if the photo-interrupter 323d reports the interruption to the controlling circuit 310k, the controlling circuit 310k further supplies the driving current to the electric motor unit 322, and causes the regulating button controller 320 to enter into the closed position CP.

If the electric motor units 310d and 322 are of a stepping motor, the shutter plates 310g and 323c exactly turn over the distance equal to the width of the shutter plates 310g and 323c.

In this instance, the controlling circuit 310k concurrently drives the electric motor units 310d and 322. The driving current may be supplied to one of the electric motor units 310d and 322, and the other electric motor unit 322 or 310d may be driven after the rotation of the shaft member 310a or 321a.

Thus, the photo-interrupters 310h/310i and 323a/323b exactly detect the free position SP/blocking position BP and the spaced position SP/closed position CP, and the controlling circuit 310k precisely positions the hammer stopper 310 and the regulating button controller 320. Moreover, an external force does not exert on the photo-interrupters 310h/310i and 323a/323b, and the photo-interrupters 310h/310i and 323a/323b are free from the aged deterioration.

After the entry into the blocking position BP and the closed position CP, the player starts a performance through a fingering on the keyboard 101. The white key 101b is assumed to be depressed. The capstan screw 103 pushes up the whippen heel 110c, and the whippen 110b and the jack 110e turn in the clockwise direction around the whippen flange 110a. The regulating button controller 320 has already decreased the distance between the tow 110g and the regulating button 110i, and the toe 110g is brought into contact with the regulating button 110i earlier than that in the acoustic sound mode. This results in an earlier escape of the jack 110e, and the hammer assembly 120 certainly starts the free rotation before the rebound on the cushion member 310c. When the jack escapes from the hammer butt 120b, the player feels the key touch usual, and the regulating button controller 320 causes the key action mechanisms 110 and the hammer assemblies 120 to give the unique key touch of the acoustic piano to the player.

Even if the player repeats the white key 101b, the cushion member 310c is sufficiently spaced from the starting point of the free rotation, and the hammer assembly 120 is never caught between the jack 110e and the cushion member 310c.

The hammer shank 120c rebounds on the cushion member 310c before a strike at the string 130, and the string 130 does not vibrate. However, the key sensor 210 monitors the motion of the depressed white key 101b, and the electronic tone generating unit 220 tailors an audio signal corresponding to the acoustic sound generated by the strings 130. The audio signal is supplied to the headphone 230, and an electronic sound is generated through the headphone 230.

The intensity of the strike is proportionally varied with the angular velocity of the hammer assembly 120 in the free rotation. The electronic tone generating unit 220 may calculate the key velocity on the basis of the lapse of time between the photo-interrupters incorporated in the key sensor 210, and estimates the hammer velocity from the key velocity.

Thus, the player can practice a fingering on the keyboard 101 without an acoustic sound, and the electronic sound generating system 200 allows the player to confirm the fingering through the electronic sounds.

If the push button switch 310m is depressed again, the controlling unit 310k changes the hammer stopper 310 and the regulating button controller 320 to the free position FP and the spaced position, and the player can perform a music through the acoustic sounds again.

The manipulating switch panel 310n may be placed in the vicinity of the keyboard 101. If so, a child easily manipulates the switches, and enjoys the performance.

As will be appreciated from the foregoing description, the non-contact sensors, i.e., the photo-detectors 310h/310i and 323a/323b do not change the detecting points on the trajectories of the shutter plates 310g/321a by virtue of the non-contact detection, and the keyboard musical instrument can run without a maintenance of the position controllers.

Moreover, the push button switch 310m and the controlling circuit 310k are shared between the hammer stopper 310 and the regulating button controller 320, and both of the hammer stopper 310 and the regulating button controller 320 are concurrently changed by manipulating the push button switch 310m. The component parts of the silent system 300 are decreased, and both of the hammer stopper 310 and the regulating button controller 320 are surely changed depending upon the mode of operation.

Second Embodiment

Turning to figure 5 of the drawings, a grand piano 400, an electronic sound generating system 500 and a silent system 600 form parts of another keyboard musical instrument embodying the present invention.

The grand piano 400 comprises a keyboard 410, a plurality of key action mechanisms 420, a plurality of hammer assemblies 430, a plurality of strings ST and a plurality of damper assemblies 440.

The keyboard 410 is implemented by turnable black/white keys 411, and is mounted on a key bed structure 412. Capstan screws 413 project from the black/white keys 411, respectively.

The key bed structure 412 has a stationary key bed 412a and a movable key bed 412b, and the movable key

bed 412b moves the stationary key bed 412a closer to and spaced from the stationary key bed 412a. The stationary key bed 412a is similar to a key bed of a standard grand piano. Namely, the stationary key bed 412a is connected to legs (not shown), and supports pedal mechanisms (not shown). A lifter is provided for the key bed structure 412, and forms a part of the silent system 500. The lifter is described in detail hereinlater together with other sub-systems of the silent system 500.

Each of the key action mechanisms 420 includes a whippen 421 turnably supported by a whippen flange fixed to a whippen rail 422 and a whippen heel 423 attached to a lower surface of the whippen 421, and the capstan screw 413 is held in contact with the whippen heel 423.

The key action mechanism 420 further includes a jack 424 turnably supported by the whippen 421, and has a generally L-shape. A tow 424a is formed on the short arm of the jack 424.

The key action mechanism 420 further includes a repetition lever flange 425 upright from the whippen 421, a repetition lever 426 turnably supported by the repetition lever flange 425 and a repetition spring 427 provided through the repetition lever flange 425 between the jack 424 and the repetition lever 426. The repetition lever 426 has a through hole, and the long arm of the jack 424 is inserted into the through hole. The repetition spring 427 urges the repetition lever 426 and the jack 424 in the counter clockwise direction.

The key action mechanism 420 further includes a regulating button mechanism 428 supported by a shank flange rail 414, and the shank flange rail 414 in turn is supported by action brackets 415. The action brackets 415 are provided on bracket blocks (not shown), respectivley, and the bracket blocks are mounted through a key frame 416 on the movable key bed 412b. The gap between the toe 424a and the regulating button mechanism 428 is regulable.

When a player depreses the key 411, the key 411 turns in the clockwise direction, and the capstan screw 413 pushes up the whippen heel 423. The whippen 421 and the jack 424 turn in the counter clockwise direction around the whippen flange, and the jack 424 forces the hammer assembly 430 to turn in the clockwise direction.

When the jack 424 is brought into contact with the regulating button mechanism 428, the jack 424 turns around the whippen 421, and escapes from the hammer assembly 430. Then, the hammer asembly 430 starts the free rotation, and rushes toward the string ST.

The hammer assembly includes a hammer shank flange 431 fixed to teh hammer shank flange rail 414, a hammer shank 432 turnably connected to the hammer shank flange 431, a hammer head 433 fixed to the leading end of the hammer shank 432 and a roller 434 rotatably supported by the hammer shank 432. While the key 411 is staying at the rest position, the roller 434 is held in contact with a top surface of the long arm of the jack 424.

While the jack 424 is pushing the roller 434, the hammer shank 432 and, accordingly, the hammer head 433 are forcibly rotated in the clockwise direction around the hammer shank flange 431. After the escape, the hammer shank 432 and the hammer head 433 continuously turn in the clockwise direction around the hammer shank flange 431.

The string ST is implemented by a plurality of wires, and is horizontally stretched over the hammer assemblies 430. When the hammer head 433 strikes the string ST, the string ST vibrates for generating an acoustic sound.

The damper mechanism 440 includes a damper lever flange 441 fixed to a damper lever rail 442, a damper lever 443 turnably suported by the damper lever flange 441, a damper head 444 turnably suported by the damper lever 443, a damper wire 445 projecting from the damper head 444 and a damper head 446 fixed to the leading end of the damper wire 445. The damper head 446 is pressed against the string ST due to the self-weight, and the leading end of the damper lever 443 is over the rear end of the key 411.

When the key 411 is depressed, the capstan screw 413 pushes up the whippen heel 423 as described hereinbefore, and the rear end of the key 411 pushes up the leading end of hte damper lever 443. The damper levelr 433 turns in the counter clockwise direction around the damper lever flange 441, and the damper head 446 leaves the string ST so as to allow the string ST to vibrate upon the strike with the hammer head 433.

The grand piano 400 thus arranged is similar to a standard grand piano, and other components such as pedal mechanisms are not described for the sake of simplicity.

The electronic sound generating system 500 comprises a plurality of hammer sensors 510 for monitoring the hammer actions, an electronic tone generating unit 520 similar to that of the first embodiemnt and a headphone 530 for generaitng electronic sounds.

Each of the hammer sensors 510 has a plurality of photo-interrupters 510a and a shutter plate 510b attached to the hammer shank 432, and reports the interruptions of the light beams of the photo-interrupters 510a.

While the player is performing a music through the electronic sounds, the hammer sensors 510 inform the electronic tone generating unit 520 of the photo-interruptions, and the electronic tone generating unit 520 calculates the hammer velocity for each rotated hammer assembly 430. The electronic tone generating unit 520 tailors an audio signal, and supplies the audio signal to the headphone 530. The headphone generates the electronic sounds, and the player confirms the music through the electronic sounds.

The silent system 600 largely comprises the lifter 610, a gap regulator 630, a hammer stopper 650, a push button switch 670 provided on a manipulating switch board 671 and a controlling circuit 680, and allows the player to perform a music without the acoustic sounds.

The lifter 610 is illustrated in figures 6 and 7 in detail. The lifter 610 is provided between the stationary key bed 412a and the movable key bend 412b, and includes four jacks 611a, 611b, 611c and 611d provided at four corners of the key bed structure 412, an electric motor unit 612, bevel gear boxes 613a and 613b, rotatable shaft members 614a, 614b, 614c, 614d and 614e, coupling units 615a, 615b, 615c, 615d, 615e, 615f, 615g, 615h, 615i, 615j and 615k and a position controller 616.

The electric motor unit 612 is powered by the controlling circuit 680, and is bi-directionally rotated. The shaft of the electric motor unit 612 is connected through the coupling unit 615i to the shaft member 614a, and the shaft member 614a is rotatably supported by a bearing unit 616a.

The shaft member 614a is connected through the coupling unit 615a to the bevel gear box 613a, and the bevel gear box 613a transfers the rotation of the shaft member 614a through the coupling units 615b and 615g to the jack 611a and the shaft member 614d.

The shaft member 614d is connected through the coupling unit 615j to the jack 611c, and the jack 611a is coupled through the coupling unit 615c to the shaft member 614b. Thus, the rotation of the shaft member 614a is transferred to not only the jacks 611a and 611c but also the shaft member 614b.

The shaft member 614b is connected through the coupling unit 615d to the jack 611b which in turn is connected through the coupling unit 615e to the bevel gear unit 613b. The bevel gear unit 613b has two output shafts, and the two output shafts are coupled through the coupling units 615f and 615h to the shaft members 614c and 614e, respectively. The shaft member 614c is rotatably supported by a bearing unit 616b, and the other shaft member 614e is connected through the coupling unit 615k to the jack 611d.

Thus, the rotation of the shaft member 614b is transferred to the other jacks 611b and 611d.

The jacks 611a to 611d are similar to one another, and a worm 611e, a worm wheel 611f and a vertical shaft 611g form in combination each of the jacks 611a to 611d.

As will be better seen in figure 6, a lower portion of the vertical shaft 611g projects through the stationary key bed 412a, and a leading end portion is threaded. The lower end portion of the vertical shaft 611g is supported by bearing members 611h, and the bearing members 611h are housed in a bearing box 611i.

The threaded leading end portion is screwed into a female screw formed in the movable key bed 412b, and, accordingly, the movable key bed 412b is supported through the vertical shafts 611h of the four jacks 611a to 611d by the stationary key bed 412a. The worm wheel 611f is fixed to an intermediate portion of the vertical shaft 611g, and is meshed with the worm 611e.

When the worms 611e are rotated in one direction, the worm wheels 611f rotate the vertical shafts 611g, and the vertical shafts 611g lifts the movable key bed 412 with respect to the stationary key bed 412a.

On the other hand, when the worms 611e are rotated in the opposite direction, the vertical shafts 611g pull down the movable key bed 412b.

Turning back to figure 7, a shutter plate 616a and photo-interrupters 616b and 616c as a whole consititute the position controller 616. The shutter plate 616a is fixed to the shaft member 614a, and the photo-interrupters 616b and 616c are similar to the photo-interrupters 310h/310i/323a/323b.

When a player pushes the push button switch 670, the electric motor unit 612 is rotated in either direction, and the movable key bed 412b is changed from an upper position to a lower position or vice versa. The movable key bed 412b stays at the upper position during the acoustic sound mode, and is changed to the lower position in the electronic sound mode. As described hereinbefore, the black and white keys 411, the key action mechanisms 420 and the hammer assemblies 430 are supported by the movable key bed 412b, and the gap bewteen the hammer heads 433 and the strings ST is increased upon the change from the acosutic sound mode to the electronic sound mode.

The gap regulator 630 includes a bracket member 631 fixed to a block member 632 stationary with respect to the stationary key bed 412a, a shaft member 633 rotatably supported by a bearing unit 634 mounted on the bracket member 631, a lever 635 bolted to the shaft member 633 and a spacer 636 fixed to the lever 635. As will be better understood, the spacer 636 has a case 636a fixed to the lever 635, and a guide slot 636b is formed in the case 636a. The gap regulator 639 further includes a plurality of sliding plates 636c slidably inserted into the guide slot 636b, and spacer blocks 636d are attached to the sliding paltes 636c, respectively. The spacer blocks 636d are respectively associated with the plurality of black and white keys 411, and the lever 635 is held in contact with the movable key bed 412b (see figure 6) by means of a spring 637. The spacer blocks 636d may be formed of a resilient material, and serve as cushions.

While the movable key bed 412b is staying at the upper position, the lever 635 and the spacer 636 decline, and the spacer blocks 636d are moved out of the trajectories of the rear end of the black and white keys 411. The position of the spacer blocks 636d out of the trajectories are called as a shunt position SH.

On teh other hand, if the movable key bed 412b is lowered, the lever 635 and the spacer 636 turn in the clockwise direction around the bearing unit 634, and the spacer blocks 636d are moved into the trajectories of the end portions of the black and white keys 411. The spacer blocks 636d are placed beneath the leading ends of the damper levers 443, and the position in the trajectories is called as a make-up position MK.

The hammer stopper 650 includes a plurality of cushion members 651 attached to the hammer shanks 651, a shank stopper 652, a driving mechanism 653 for the shank stopper 652 and a position controller 654, and figure 9 illustrates the shank stopper 652.

The shank stopper 652 has frames 652a, guide rods 652b fixed to the frames 652a, sliders 652c slidably supported by the guide rods 652b and a stopper plate 652d fixed to the sliders 652c and moved by the driving mechanism 653. The key action mechanisms 420 are grouped into three sections, i.e., the key action mechanisms for low pitch tones, the key action mechanisms for middle pitch tones and the key action mechanisms for high-pitch tones. The frames 652a are provided on both sides of the key action mechanisms 420 and between the three sections, and are supported by the whippen rail 422 and the action brackets 415. The guide rods 432 are oblique, and the stopper plate 652d is changed in height from the movable key bed 412b depending upon the position of the sliders 652c on the guide rods 652b.

While the keyboard musical instrument is staying in the acoustic sound mode, the stopper plate 652d is out of the trajectories of the hammer shanks 432, and the hammer heads 433 strike the strings ST without an interruption of the stopper plate 652d. This position is called as a free position FP.

On the other hand, if the keyboard musical instrument is changed to the electronic sound mode, the stopper plate 652d is confronted with the cushion members 651, and the cushion members rebound on the stopper plate 652d before a strike with the hammer head 433 against the string ST. This position is called as a blocking position BP.

The driving mechanism 653 is illustrated in figure 10, and includes coil spring 653a connected between the sliders 652c and the frame 652a, side plate members 653b connected to both sides of the stopper plate 652d, flexible wires 653c connected between the side plate members 653b and a pulley 653d and an electric motor unit 653e fixed to a stationary board member 655 forming a part of the piano case. Idle pulleys 652f turn back the flexible wires 653c, and change the motion of the flexible wires 653c.

The position controller 654 includes a shutter plate 654a and two photo-interrupters 654b and 654c. The photo-interrupters 654b and 654c are similar to those of the first embodiment, and the shutter plate 654a interrupts the light beam of the photo-interrupter 654b at the blocking position BP and the light beam of the photo-interrupter 654c at the free position FP. The detection of the free position FP and the detection of the blocking position BP are reported to the controlling circuit 680.

The electric motor unit 653e is controlled by the controlling circuit 680. Namely, if the player depresses the push button switch 670 in the acoustic sound mode, the controlling circuit 680 supplies driving current to the electric motor unit 653e, and the flexible wires 653c are wound on the pulley 653d. The side plate members 653b and the sliders 652c are rearwardly moved. When the shutter plate 654a interrupts the light beam of the photo-interrupter 654b, the stopper plate 652d enters into the blocking position BP, and the controlling circuit 680 stops the driving current.

On the other hand, if the player depresses the push button switch 670 in the electronic sound mode, the controlling circuit 680 confirms the present position of the hammer stopper 650, and supplies the driving current to the electric motor unit 653e. The flexible wires 653c are wound off, and the coil springs 653a urge the sliders 652c and the stopper plate 652d. When the shutter plate 654a interrupts the light beam of the photo-interrupter 654c, the controlling circuit 680 stops the driving current, and the hammer stopper 650 enters into the free position FP.

The keyboard musical instrument behaves in the acoustic sound mode as follows. Assuming now that the keyboard musical instrument has entered into the electronic sound mode, a player depresses the push button switch 670, and the controlling circuit 680 confirms the blocking position BP and the lower position. If the hammer stopper 650 and/or the lifter 610 are not in the blocking position BP and/or the lower position, the controlling circuit 680 regulates the hammer topper 650 and the lifter 610 as similar to the first embodiment described in conjunction with figures 4A and 4B.

The controlling circuit 680 supplies the driving current to the electric motor units 653e and 612. The electric motor unit 653e winds off the flexible wires 653c until the shutter plate 654a interrupts the light beam of the photo-interrupter 654c, and the hammer stopper 650 enters into the free position FP.

Similarly, the electric motor unit 612 rotates the shaft member 614a until the shutter plate 616a interrupts the light beam of the photo-interrupter 616b, and the jacks 611a to 611d pushes up the movable key bed 412b. The movable key bed 412b enters into the upper position.

When the movable key bed 412b is in the upper position, the gap between the strings ST and the hammer heads 433 are adjusted to appropriate values equal to the standard grand piano.

The movable key bed 412b rotates the lever 635 in the counter clockwise direction, and the spacer blocks 636d are changed to the shunt position SH.

The player starts the performance on the keyboard, and the key 411 is assumed to be depresses. The key turns in the clockwise direction, and the capstan screw 413 pushes up the whippen heel 423. The whippen 421 and the jack 424 turns in the counter clockwise direction around the whippen flange, and the jack 424 pushes up the hammer assembly 430. The hammer shank 432 and the hammer head 433 turn in the clockwise direction around the hammer shank flange 431.

The rear end portion of the key 411 pushes up the damper lever 443, and the damper head 446 leaves the string ST.

When the toe 424a is brought into contact with the regulating button mechanism 428, the jack 424 quickly turns around the whippen 421, and escapes from the hammer roller 434. The jack 424 imparts kinetic energy to the hammer assembly 430 upon the escape, and the hammer assembly 430 starts a free rotation in the clockwise direction around the hammer shank flange 431.

The hammer head 433 strikes the string ST, and rebounds thereon. The string ST vibrates for generating the acoustic sound. After the player releases the depressed key 411, the hammer assembly 430 returns to the home position, and the jack 424 returns to the initial position beneath the hammer roller 434.

Subsequently, the player wants to play the keyboard musical instrument in the electronic sound mode. The player depresses the push button switch 670, and the controlling circuit 680 supplies the driving current to the electric motor unit 653e and 612.

The electric motor unit 653e winds the flexible wires 653c on the pulley 653d until the shutter plate 654a interrupts the light beam of the photo-interrupter 654b, and the hammer stopper 650 enters into the blocking position BP.

The electric motor unit 612 rotates the shaft member 614a vice versa until the shutter plate 616a interrupts the light beam of the photo-interrupter 616c. The jacks 411a to 411d pull down the movable key bed 412b, and the movable key bed 412b enters into the lower position. In this situation, though the gap between the toes 424a and the regulating button mechanisms 428 is unchanged, the hammer assemblies 430 are spaced from the strings ST.

The downward motion of the movable key bed 412b allows the lever 635 to turn in the clockwise direction, and the gap spacer blocks 636d enter into the make-up position.

The player can start a fingering on the keyboard. While the player is performing the music, the key 411 is assumed to be depressed. The capstan screw 413 pushes up the whippen heel 423, and the whippen 421 and the jack 424 turn in the counter clockwise direction around the whippen flange. The jack 424 pushes up the hammer roller 434, and the hammer assembly 430 turns in the clockwise direction around the hammer shank flange 431.

The rear end portion of the key 411 is brought into contact with the spacer block 636d. The slider 636 upwardly slides, and the rear end portion of the key 411 rotates the damper lever 443. As a result, the damper head 446 leaves the string ST, and the damper head 446 provides a load to the key 411 as similar to the acoustic sound mode.

When the toe 424a is brought into contact with the regulating button mechanism 428, the jack 424 quickly turns around the whippen 421, and escapes from the hammer roller 434 before the interruption of the rotation of the hammer assembly 430. Thus, the jack 424 surely escapes from the hammer roller 434, and the player feels the key touch as usual.

The hammer assembly 430 starts the free rotation, and the cushion member 651 rebounds on the stopper plate 652d. The hammer action is monitored by the hammer sensor 510a, and the electronic tone generating unit 520 tailors an audio signal. The audio signal is supplied to the headphone 530, and generates the electronic sound having the note corresponding to the acoustic sound.

When the player releases the depressed key 411, the hammer assembly 430 returns to the home position, and the jack 424 returns to the initial position beneath the hammer roller 434.

As will be understood from the foregoing description, the photo-interrupters 616b/616c and 654b/654c detect the shutter plates 616a/654a without an physical contact, and the detecting points are not permanently changed. Moreover, the controlling circuit 680 is responsive to the push button switch 670 so as to concurrently change the hammer stopper 650, the lifter 610 and the gap regulator 630, and the player is released from a complicated manipulation.

Third Embodiment

Figures 11 and 12 illustrate yet another keyboard musical instrument embodying the present invention. The keyboard musical instrument implementing the third embodiment also comprises a grand piano, an electronic sound generating system and a silent system. The grand piano and the electronic sound system are similar to those of the second embodiment, and a gap regulator 700 of the silent system is only different from the gap regulator 630. For this reason, the gap regulator 700 is described hereinbelow in detail. The similar components are designated in the following description by using the same references as the second embodiment.

The gap regulator 700 is placed under the damper mechanisms 440, and largely comprises a spacer mechanism 701, an electric motor unit 702 and a position controller 703. Thought the gap regulator 630 is changed by the movable key bed 412b, the gap regulator 700 is directly controlled by the controlling circuit 680.

The spacer mechanism 701 includes a base plate member 701a extending in the lateral direction of the grand piano and an elongated case 701b having a slot 701c formed in the front surface thereof, and the slot 701c is directed to the rear end of the black and white keys 411.

The spacer mechanism 701 further includes a sliding block 701d accommodated in the elongated case 701b, and an elongated hollow space 701e is open at the bottom surface of the sliding block 701d. The elongated hollow space 701e is aligned with an elongated opening 701f formed in the base plate member 701a and the bottom plate of the elongated case 701b.

The spacer mechanism 701 further includes a plurality of leaf spring members 701g fixed to the sliding block 701d at intervals, and the leading end portions of the leaf spring members 701g project from the slot 701c.

The spacer mechanism 700 further includes a plurality of cushion blocks 701h formed of felt, and the plurality of cushion blocks 701h are attached to the leading end portions of the leaf spring members 701g. The leaf spring members 701g and, accordingly, the cushion members 701h are associated with the plurality of black and white keys 411 as well as the damper mechanisms 440.

The electric motor unit 702 is connected to a shaft member 702a, and the shaft member 702a is rotatably supported by bearing units 702b at intervals. A plurality of pushers 702c are fixed to the shaft member 702a at intervals, and pass the opening 701f so as to reach the elongated hollow space 701e. The controlling circuit 680 bi-directionally rotates the electric motor unit 702, and pushers 702c reciprocally slide the sliding block 701d in the elongated case 701b.

The position controller 703 includes a shutter plate 703a attached to the shaft member 702a and two photo-interrupters 703b and 703c provided on both sides of the shaft member 702a, and the shutter plate 703a selectively interrupts the light beams of the photo-interrupters 703b and 703c. The photo-interrupters 703b and 703c are similar to those of the first and second embodiments.

The gap regulator 700 thus arranged behaves as follows. If a player depresses the push button switch 670 so as to change the keyboard musical instrument to the electronic sound mode, the controlling circuit 680 concurrently supplies the driving current to the electric motor units 612 and 653e, and the hammer stopper 650 and the movable key bed 412b are changed to the blocking position BP and the lower position. The electric motor units 612 and 653e may start the rotation at different timings.

When the shutter plate 616a interrupts the photo-interrupter 616c, the controlling circuit 680 acknowledges the lower position, and stops the driving current to the electric motor unit 612. Thereafter, the controlling circuit 680 supplies the driving current to the electric motor unit 702, and the electric motor unit 702 rotates the shaft member 702a in the counter clockwise direction.

The pushers 702c slide the sliding block 701d to the left side, and the leaf spring members 701g projects from the slot 701c. The cushion blocks 701h are respectively placed beneath the leading ends of the damper levers 443.

When the cushion blocks 701h reach the positions beneath the damper levers 443, the shutter plate 703a interrupts the light beam of the photo-interrupter 703b, and the controlling circuit 680 acknowledges the make-up position MK. Then, the controlling circuit 680 stops the driving current.

On the other hand, if the player depresses the push button switch 670 so as to change the keyboard musical instrument to the acoustic sound mode, the controlling circuit 680 firstly supplies the driving current to the electric motor unit 702, and the electric motor unit 702 rotates the shaft member 702a in the clockwise direction. The controlling circuit may concurrently supply the driving current to the electric motor unit 653e so as to change the hammer stopper 650 to the free position FP.

The pushers 702c backwardly slide the sliding block 701d, and the leaf spring members 701g are retracted into the elongated case 701b.

When the cushion blocks 701h are moved out of the trajectories of the rear end portions of the black and white keys 411, the shutter plate 703a interrupts the light beam of the photo-interrupter 703c, and the controlling circuit 680 acknowledges the shunt position SH. Then, the controlling circuit 680 stops the driving current supplied to the electric motor unit 702.

Thereafter, the controlling circuit 680 supplies the driving current to the electric motor unit 612, and changes the movable key bed 412b to the upper position.

Thus, the all of the position controllers 616, 654 and 703 are implemented by the non-contact sensors, and the detecting points are permanently unchanged. The controlling circuit 680 releases the player from complicated manipulation.

Moreover, the controlling circuit 680 supplies the driving current to the electric motor units 612 and 702 at different timings, and the movable key bed 412b is never brought into collision with the gap regulator 701.

Fourth Embodiment

Figures 13 and 14 illustrate a muting system 750 incorporated in still another keyboard musical instrument embodying the present invention. The keyboard musical instrument implementing the fourth embodiment comprises a grand piano, an electronic sound generating system, a silent system and the muting system 750, and the grand piano, the electronic sound system and the silent system are similar to those of the second embodiment. For this reason, components of these systems are labeled with the same references in the following description.

The muting system 750 includes a generally inverted L-shaped bracket member 751 bolted to the shank rail 414, an auxiliary regulating button mechanism 752 rotatably supported by bearing units 752a on the generally inverted L-shaped bracket member 751 and an auxiliary toe 753 formed on the short portion of the jack 424. The auxiliary regualting button mechanism 752 is changed between an enabled position ENB and disabled position DSA by an electric motor unit (not shown) associated with a position controller (not shown). The electric motor unit and the position controller are similar to those shwon in figure 2, and are connected to the controlling circuit 680.

While the auxiliary regulating button mechanism 750 is staying in the disabled position DSA, the keyboard musical instrument behaves in the acosutic sound mode.

On the other hand, when the auxiliary regulating button mechanism 750 enters into the enabled position ENB, the auxiliary toe 753 is brought into contact with the auxiliary regulating button mechanism 752, and the jack 424 turns in the clockwise direction at an angular speed greater than the turn upon the contact between the toe 424a and the regualting button mechanism 428. This results in a quick escape, and the jack 424 imparts a kinetic energy smaller than that in the acoustic sound mode to the hammer assembly 430. For this reason, the hammer heads 433 softly strike the stirings ST, and the strings ST weakly vibrate.

The auxiliary regulating button mechanism 752 includes a shaft member 752b connected to the electric motor unit (not shown), a plurality of bushes 752c inserted into the shaft member 752b at intervals and a plurality of auxiliary regulating screws 752d respectively associated with the jacks 424 and screwed into the bushes 752c. When the auxiliary regulating screw 752d is rotated, the auxiliary regulating screw 752d is retracted into and projects from the bush 752c.

The auxiliary regulating screws 752d have respective heads 752e, and the auxiliary regulating button mechanism 752 further includes a plurlity of cases 752f, pairs of clothes 752g inserted between the heads 752e and hte cases 752f and a plurality of cushion sheets 752h attached to the lower surfaces of the cases 752f, respectively.

Another push button switch (not shown) is assigned the muting system 750. When the push button switch is depressed by a player in the acosutic sound mode, the controling circuit 680 supplies the driving current to the electric motor unit, and the shaft member 752b is rotated in the clockwise direction. When the shutter plate interrupts the light beam of one of the photo-interrupters, the controlling circuit 680 acknowledges the enty into the enabled position ENB, and stops the driving current.

If the player depresses the push button switch again, the contrlling circuit supplies the driving current to the electric motor unit, and hte shaft member 752b is rotated in te counter clockwise direction. When the shutter plate interrupts the light beam of the other of the photo-interrupters, the controlling circuit 680 acknowledges the disabled position DSA, and stops the driving current.

Thus, the enabled position ENB and the disabled position DSA are defined by the non-contact sensors, and are not affected by undesirable force due to a physical contact.

Modifications

An electric motor unit may be directly coupled to a shaft member or coupled through a suitable transfer mechanism such as, for example, a reduction gear unit a belt and pulleys.

Figure 15 illustrates a flexible coupling 800 between a shaft member and an output shaft 801 of an electric motor unit 803 mounted on a bracket 804 fixed to a side board 805. A print board 806 is attached to the bracket 804, and a position controller 807, i.e., a shutter plate 807a and photo-interrupters 807b are provided for the electric motor unit 803. The flexible coupling 800 absorbs mis-alignment between the output shaft 802 and the shaft member 801.

A keyboard musical instrument according to the present invention may produce both of the acoustic sounds and the electronic sounds, and a foot pedal may be used for the concurrent sound generation. Namely, if a player depresses the foot pedal, the electronic sound generating system is powered regardless of the position of the hammer stopper. On the other hand, if the foot pedal is laterally moved after the step-on, the controlling circuit supplies the driving current to the electric motor units so as to change the hammer stopper and the regulating button controller/the movable key bed.

A modification of the second embodiment may horizontally keep the movable key bed in the acoustic sound mode and decline it in the electronic sound mode. The turning axis of the movable key bed is provided in the vicinity of the keyboard, and listener hardly notices the declination of the front end of the movable key bed.

A modification of the first embodiment, if the electric motor unit stops the hammer stopper between the free position and the blocking position, a player can perform a music through soft sounds. In this instance, an additional photo-interrupter may be placed between the two photo-interrupters.

A modification of the position controller may have a sector shutter plate 900 attached to an output shaft 901 of an electric motor unit 902 and photo-interrupters 903 and 904 as shown in figure 16. Figures 17A to 17D illustrate various relative positions of the sector shutter plate 900 with respect to the light beams of the photo-interrupters 903 and 904.

When the keyboard musical instrument is in the acoustic sound mode, the sector shutter plate 900 interrupts the light beam of the photo-interrupter 904, and the other photo-interrupter 903 establishes the optical path.

The sector shutter plate 900 is rotated in the clockwise direction, and the sector shutter plate 900 firstly interrupts the light beam of the photo-interrupter 903. Thereafter, the sector shutter plate 900 allows the photo-interrupter 904 to establish the optical path, and the controller acknowledges the entry into the blocking position.

Similarly, if the sector shutter plate 900 is rotated in the counter clockwise direction, and the sector shutter plate 900 firstly interrupts the light beam of the photo-interrupter 904. Thereafter, the sector shutter plate 900 allows the photo-interrupter 903 to establish the optical path, and the controller acknowledges the entry into the free position.

In this instance, the unusual state shown in figures 4A and 4B are corresponding to the relative positions shown in figures 17C and 17D.

The sector shutter plate 900 may be replaced with a sector shutter plate 910 shown in figure 18.

Although particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the present invention.

First, a silent system of a keyboard musical instrument according to the present invention may include the hammer stopper only. That is, the regulating button controller is omitted from the keyboard musical instrument.

Solenoid-operated actuator units may be respectively provided under the black and white keys 101a/101b for an automatic playing, and the keyboard musical instrument equipped with the solenoid-operated actuator units may record and reproduce an original performance

through the keyboard 101. In this instance, the keyboard musical instrument has the acoustic sound mode, the electronic sound mode and a recording/reproducing mode.

In the keyboard musical instrument equipped with the solenoid-operated actuator units, the positions of the hammer sensors may be changed between a recording mode and the electronic sound mode, because the final hammer velocity is strictly proportional to the intensity of hammer's impact.

The electronic sounds may selectively impart other timbres such as an organ, cembalo and celesta to the electronic sounds.

Although the photo-interrupters are used in the embodiments, another non-contact type position sensor may be installed in the keyboard musical instrument. The non-contact type position sensor may generate electric signals indicative of the free position Fp, the blocking position BP, the spaced position SP and the closed position CP through an electro-magnetic phenomenon, by way of example.

The electric motor units may be replaced with another kind of actuator such as, for example, a solenoid-operated actuator unit. The electronic tone generating unit 220 may supply the audio signal to a speaker system instead of or together with the headphone 230.

It should be noted that the objects and advantages of the invention may be attained by means of any compatible combination(s) particularly pointed out in the items of the following summary of the invention and the appended claims.

SUMMARY OF THE INVENTION

1. A keyboard musical instrument having at least an acoustic sound mode for generating acoustic sounds and an electronic sound mode for generating electronic sounds, comprising:

an acoustic piano (100; 400) including

a keyboard (101) having a plurality of turnable keys (101a/101b; 411) respectively assigned notes of a scale and selectively depressed by a player in both of said acoustic sound mode and said electronic sound mode,

a plurality of string means (130; ST) for generating said acoustic sounds in said acoustic sound mode,

a plurality of hammer assemblies (120; 430) respectively associated with said plurality of string means (130; ST) and driven for rotation for striking said plurality of string means in said acoustic sound mode, and

a plurality of key action mechanisms (110; 420) functionally connected between said plurality of turnable keys (101a/101b; 411) and said plurality of hammer assemblies (120; 430), respectively, and having respective jacks (110e; 424) escaping from said plurality of hammer assemblies (120; 430) when said plurality of keys (101a/101b; 411) are depressed by said player;

an electronic sound generating system (200; 500) for generating said electronic sounds having the notes corresponding to the keys depressed by said player in said electronic sound mode; and

a silent system (300; 600) including

a hammer stopper (310; 650) having

an interrupter (310a/310b/310c; 651/652d) changed between a free position (FP) and a blocking position (BP), said interrupter (310a/310b/310c; 651/652d) entering into said free position (FP) in said acoustic sound mode so as to allow said plurality of hammer assemblies (120; 430) to strike said plurality of string means (130; ST), said interrupter (310a/310b/310c; 651/652d) entering into said blocking position (BP) in said electronic sound mode so as to cause said plurality of hammer assemblies (120; 430) to rebound thereon before a strike at said plurality of string means (130; ST), and

a first actuator means (310d; 653b/653c/653d/653e) responsive to an instruction of said player so as to change said hammer stopper (310; 650) between said free position (FP) and said blocking position (BP),

characterized in that

said hammer stopper further includes

a first position controller having a first non-contact sensor (310i; 654c) operative to detect said interrupter (310a/310b/310c; 651/652d) upon an entry into said free position (FP) and a second non-contact sensor (310h; 654b) for detecting said interrupter (310a/310b/310c; 651/652d) upon an entry into said blocking position (BP), said first actuator means (310d; 653b/653c/653d/653e) stopping said interrupter (310a/310b/310c; 651/652d) when said first non-contact sensor (310i; 654c) and said second non-contact sensor (310h; 654b) report the entry into said free position (FP) and the entry into said blocking position (BP).

2. The keyboard musical instrument

in which said first non-contact sensor (310i; 654c) and said second non-contact sensor (310h; 654b) detect said entry into said free position (FP) and said entry into said blocking position (BP) by using respective light beams.

3. The keyboard musical instrument

in which said first position controller further has a shutter plate (310g; 654a) fixed to said interrupter in such a manner as to interrupt the light beam of said first non-contact sensor (310i; 654c) at said free position (FP) and the light beam of said second non-contact sensor (310h; 654b) at said blocking position (BP).

4. The keyboard musical instrument

in which said plurality of key action mechanisms (110) have respective regulating button mechanisms (110h) operative to cause said jacks (110e) to respectively escape from said plurality of hammer assemblies (120),

said silent system (300) further including

a regulating button controller (320) provided for said plurality of regulating button mechanisms (110h) and operative to change a gap between each of said plurality of regulating button mechanisms (110h) and associated one of said jacks (110e) between said acoustic sound mode and said electronic sound mode,

said regulating button controller (320) having

a bracket member (321c) connected to said plurality of regulating button mechanisms (110h),

a second actuator means (322) connected to said bracket member (321c) and responsive to said instruction of said player for changing said plurality of regulating button mechanisms (110h) between a spaced position (SP) and a closed position (CP), said plurality of regulating button mechanisms (110h) staying at said spaced position (SP) in said acoustic sound mode and at said closed position (CP) in said electronic sound mode, and

a second position controller having a third non-contact sensor (323a) operative to detect said regulating button mechanisms (110h) upon an entry into said spaced position (SP) and a fourth non-contact sensor (323b) for detecting said regulating button mechanisms (110h) upon an entry into said closed position (CP), said second actuator means (322) stopping said bracket member (321c) when said third non-contact sensor (323a) and said fourth non-contact sensor (323b) report the entry into said spaced position (SP) and the entry into said closed position (CP).

5. The keyboard musical instrument

in which said silent system (300) further includes

a controlling sub-system (310k/310m) manipulated by said player for providing said instruction to said first and second actuator means (310d/322).

6. The keyboard musical instrument

in which said acoustic piano is a grand piano, and said plurality of strings (ST) are stretched over said plurality of hammer assemblies (430),

said acoustic piano further comprising a key bed structure (412) having a stationary key bed (412a) stationary with respect to said plurality of strings (ST) and a movable key bed (412b) movable between an upper position and a lower position with respect to said stationary key bed (412a) and supporting said keyboard (411), said plurality of key action mechanisms (420) and said plurality of hammer assemblies (430),

said silent system (600) further including a lifter (610) having

a second actuator means (612),

jack means (611a/611b/611c/611d) provided between said stationary key bed (412a) and said movable key bed (412b) and actuated by said second actuator means (612) so as to change said movable key bed between said upper position in said acoustic sound mode and said lower position in said electronic sound mode, and

a second position controller (616) having a third non-contact sensor (616b) operative to detect said movable key bed (412b) upon an entry into said upper position and a fourth non-contact sensor (616c) for detecting said movable key bed (412b) upon an entry into said lower position, said second actuator means (612) stopping said movable key bed (412b) when said third non-contact sensor (616b) and said fourth non-contact sensor (616c) report the entry into said upper position and the entry into said lower position.

7. The keyboard musical instrument

in which said acoustic piano (400) further comprises a plurality of damper mechanisms (440) respectively associated with said plurality of strings (ST) and moved by said plurality of keys (411) so as to leave said plurality of strings (ST) before said plurality of hammer assemblies (430) strike the associated strings (ST) in said acoustic sound mode,

said silent system (600) further including

a gap regulator (630) having

a motion transferring means (635) linked with said movable key bed (412b), and

a plurality of spacers (636) functionally connected to said motion transferring means (635) and moved out of trajectories of said plurality of keys (411) in said acoustic sound mode and into said trajectories of said plurality of keys (411) in said electronic sound mode for transferring motions of said plurality of keys (411) to said plurality of damper mechanisms (440), respectively.

8. The keyboard musical instrument

in which said acoustic piano further comprises a plurality of damper mechanisms (440) respectively associated with said plurality of strings (ST) and moved by said plurality of keys (411) so as to leave said plurality of strings (ST) before said plurality of hammer assemblies (430) strike the associated strings (ST) in said acoustic sound mode,

said silent system further including

a gap regulator (700) having

a third actuator means (702) responsive to said instruction,

a plurality of spacers (701) functionally connected to said third actuator means (702) so as to be changed between a shunt position (SH) and a make-up position (MK), said plurality of spacers (701) in said shunt position (SH) being out of trajectories of said plurality of keys (411) in said acoustic sound mode, said plurality of spacers (701) in said make-up position (MK) being in said trajectories of said plurality of keys (411) in said electronic sound mode for transferring motions of said plurality of keys (411) to said plurality of damper mechanisms (440), respectively, and

a third position controller (703) having a fifth

non-contact sensor (703b) operative to detect said plurality of spacers (701) upon an entry into Said shunt position (SH) and a sixth non-contact sensor (703c) for detecting said plurality of spacers (701) upon an entry into said make-up position (MK), said third actuator means (702) stopping said plurality of spacers (701) when said fifth non-contact sensor (703b) and said sixth non-contact sensor (703c) report the entry into said shunt position (SH) and the entry into said make-up position (MK).

9. The keyboard musical instrument

in which said silent system further includes a controlling sub-system (670/680) manipulated by said player for providing said instruction to said first, second and third actuator means (653e/612/702).

10. The keyboard musical instrument

in which said controlling sub-system starts said second actuator means earlier than said third actuator means when said instruction is indicative of the change from said acoustic sound mode to said electronic sound mode,

said controlling sub-system starting said third actuator means (702) earlier than said second actuator means (612) when said instruction is indicative of the change from said electronic sound mode to said acoustic sound mode.

11. The keyboard musical instrument

further comprising

a muting system (750) changed between an enabled position (ENB) and a disabled position (DSA) during said acoustic sound mode, and associated with said jacks (424) so as to decrease a kinetic energy imparted to said plurality of hammer assemblies (430) upon escapes of said jacks (424) therefrom.

12. The keyboard musical instrument

said acoustic piano further includes regulating mechanisms (428) with which toes (424a) of said jacks (424) are brought into contact for escaping from said hammer assemblies (430),

said muting system (750) including

an auxiliary toes (753) respectively provided on said jacks (424) closer to turning axes of said jacks (424) than said toes (424a), and

auxiliary regulating button mechanisms (752) changed between said enabled position (ENB) and said disabled position (DSA), said toes (424a) being brought into contact with said regulating button mechanisms (428) without a contact between said auxiliary toes (753) and said auxiliary regulating mechanisms (752) in said disabled position (DSA), said auxiliary toes (753) being brought into contact with said auxiliary regulating button mechanisms (752) in said enabled position (ENB) so that said jacks (424) turn around said turning axes faster.

Claims

1. A keyboard musical instrument having at least an acoustic sound mode for generating acoustic sounds and an electronic sound mode for generating electronic sounds, comprising:

an acoustic piano (100; 400) including

a keyboard (101) having a plurality of turnable keys (101a/101b; 411) respectively assigned notes of a scale and selectively depressed by a player in both of said acoustic sound mode and said electronic sound mode,

a plurality of string means (130; ST) for generating said acoustic sounds in said acoustic sound mode,

a plurality of hammer assemblies (120; 430) respectively associated with said plurality of string means (130; ST) and driven for rotation for striking said plurality of string means in said acoustic sound mode, and

a plurality of key action mechanisms (110; 420) functionally connected between said plurality of turnable keys (101a/101b; 411) and said plurality of hammer assemblies (120; 430), respectively, and having respective jacks (110e; 424) escaping from said plurality of hammer assemblies (120; 430) when said plurality of keys (101a/101b; 411) are depressed by said player;

an electronic sound generating system (200; 500) for generating said electronic sounds having the notes corresponding to the keys depressed by said player in said electronic sound mode; and

a silent system (300; 600) including

a hammer stopper (310; 650) having

an interrupter (310a/310b/310c; 651/652d) changed between a free position (FP) and a blocking position (BP), said interrupter (310a/310b/310c; 651/652d) entering into said free position (FP) in said acoustic sound mode so as to allow said plurality of hammer assemblies (120; 430) to strike said plurality of string means (130; ST), said interrupter (310a/310b/310c; 651/652d) entering into said blocking position (BP) in said electronic sound mode so as to cause said plurality of hammer assemblies (120; 430) to rebound thereon before a strike at said plurality of string means (130; ST), and

a first actuator means (310d; 653b/653c/653d/653e) responsive to an instruction of said player so as to change said hammer stopper (310; 650) between said free position (FP) and said blocking position (BP),

characterized in that

said hammer stopper further includes

a first position controller having a first non-contact sensor (310i; 654c) operative to detect said interrupter (310a/310b/310c; 651/652d) upon an entry into said free position (FP) and a second non-contact sensor (310h; 654b) for detecting said interrupter (310a/310b/310c; 651/652d) upon an entry

into said blocking position (BP), said first actuator means (310d; 653b/653c/653d/653e) stopping said interrupter (310a/310b/310c; 651/652d) when said first non-contact sensor (310i; 654c) and said second non-contact sensor (310h; 654b) report the entry into said free position (FP) and the entry into said blocking position (BP).

2. The keyboard musical instrument as set forth in claim 1, in which said first non-contact sensor (310i; 654c) and said second non-contact sensor (310h; 654b) detect said entry into said free position (FP) and said entry into said blocking position (BP) by using respective light beams and wherein preferably

said first position controller further has a shutter plate (310g; 654a) fixed to said interrupter in such a manner as to interrupt the light beam of said first non-contact sensor (310i; 654c) at said free position (FP) and the light beam of said second non-contact sensor (310h; 654b) at said blocking position (BP).

3. The keyboard musical instrument as set forth in claim 1, in which said plurality of key action mechanisms (110) have respective regulating button mechanisms (110h) operative to cause said jacks (110e) to respectively escape from said plurality of hammer assemblies (120),

said silent system (300) further including

a regulating button controller (320) provided for said plurality of regulating button mechanisms (110h) and operative to change a gap between each of said plurality of regulating button mechanisms (110h) and associated one of said jacks (110e) between said acoustic sound mode and said electronic sound mode,

said regulating button controller (320) having

a bracket member (321c) connected to said plurality of regulating button mechanisms (110h),

a second actuator means (322) connected to said bracket member (321c) and responsive to said instruction of said player for changing said plurality of regulating button mechanisms (110h) between a spaced position (SP) and a closed position (CP), said plurality of regulating button mechanisms (110h) staying at said spaced position (SP) in said acoustic sound mode and at said closed position (CP) in said electronic sound mode, and

a second position controller having a third non-contact sensor (323a) operative to detect said regulating button mechanisms (110h) upon an entry into said spaced position (SP) and a fourth non-contact sensor (323b) for detecting said regulating button mechanisms (110h) upon an entry into said closed position (CP), said second actuator means (322) stopping said bracket member (321c) when said third non-contact sensor (323a) and said fourth non-contact sensor (323b) report the entry into said spaced position (SP) and the entry into said closed position (CP).

4. The keyboard musical instrument as set forth in claim 3, in which said silent system (300) further includes

a controlling sub-system (310k/310m) manipulated by said player for providing said instruction to said first and second actuator means (310d/322).

5. The keyboard musical instrument as set forth in claim 1, in which said acoustic piano is a grand piano, and said plurality of strings (ST) are stretched over said plurality of hammer assemblies (430),

said acoustic piano further comprising a key bed structure (412) having a stationary key bed (412a) stationary with respect to said plurality of strings (ST) and a movable key bed (412b) movable between an upper position and a lower position with respect to said stationary key bed (412a) and supporting said keyboard (411), said plurality of key action mechanisms (420) and said plurality of hammer assemblies (430),

said silent system (600) further including a lifter (610) having

a second actuator means (612),

jack means (611a/611b/611c/611d) provided between said stationary key bed (412a) and said movable key bed (412b) and actuated by said second actuator means (612) so as to change said movable key bed between said upper position in said acoustic sound mode and said lower position in said electronic sound mode, and

a second position controller (616) having a third non-contact sensor (616b) operative to detect said movable key bed (412b) upon an entry into said upper position and a fourth non-contact sensor (616c) for detecting said movable key bed (412b) upon an entry into said lower position, said second actuator means (612) stopping said movable key bed (412b) when said third non-contact sensor (616b) and said fourth non-contact sensor (616c) report the entry into said upper position and the entry into said lower position.

6. The keyboard musical instrument as set forth in claim 5, in which said acoustic piano (400) further comprises a plurality of damper mechanisms (440) respectively associated with said plurality of strings (ST) and moved by said plurality of keys (411) so as to leave said plurality of strings (ST) before said plurality of hammer assemblies (430) strike the associated strings (ST) in said acoustic sound mode,

said silent system (600) further including

a gap regulator (630) having

a motion transferring means (635) linked with said movable key bed (412b), and

a plurality of spacers (636) functionally connected to said motion transferring means (635) and moved out of trajectories of said plurality of keys (411) in said acoustic sound mode and into said tra-

jectories of said plurality of keys (411) in said electronic sound mode for transferring motions of said plurality of keys (411) to said plurality of damper mechanisms (440), respectively.

7. The keyboard musical instrument as set forth in claim 5, in which said acoustic piano further comprises a plurality of damper mechanisms (440) respectively associated with said plurality of strings (ST) and moved by said plurality of keys (411) so as to leave said plurality of strings (ST) before said plurality of hammer assemblies (430) strike the associated strings (ST) in said acoustic sound mode, said silent system further including

a gap regulator (700) having

a third actuator means (702) responsive to said instruction,

a plurality of spacers (701) functionally connected to said third actuator means (702) so as to be changed between a shunt position (SH) and a make-up position (MK), said plurality of spacers (701) in said shunt position (SH) being out of trajectories of said plurality of keys (411) in said acoustic sound mode, said plurality of spacers (701) in said make-up position (MK) being in said trajectories of said plurality of keys (411) in said electronic sound mode for transferring motions of said plurality of keys (411) to said plurality of damper mechanisms (440), respectively, and

a third position controller (703) having a fifth non-contact sensor (703b) operative to detect said plurality of spacers (701) upon an entry into said shunt position (SH) and a sixth non-contact sensor (703c) for detecting said plurality of spacers (701) upon an entry into said make-up position (MK), said third actuator means (702) stopping said plurality of spacers (701) when said fifth non-contact sensor (703b) and said sixth non-contact sensor (703c) report the entry into said shunt position (SH) and the entry into said make-up position (MK).

8. The keyboard musical instrument as set forth in claim 7, in which said silent system further includes a controlling sub-system (670/680) manipulated by said player for providing said instruction to said first, second and third actuator means (653e/612/702) and

wherein preferably

said controlling sub-system starts said second actuator means earlier than said third actuator means when said instruction is indicative of the change from said acoustic sound mode to said electronic sound mode,

said controlling sub-system starting said third actuator means (702) earlier than said second actuator means (612) when said instruction is indicative of the change from said electronic sound mode to said acoustic sound mode.

9. The keyboard musical instrument as set forth in claim 1, further comprising

a muting system (750) changed between an enabled position (ENB) and a disabled position (DSA) during said acoustic sound mode, and associated with said jacks (424) so as to decrease a kinetic energy imparted to said plurality of hammer assemblies (430) upon escapes of said jacks (424) therefrom and

wherein preferably

said acoustic piano further includes regulating mechanisms (428) with which toes (424a) of said jacks (424) are brought into contact for escaping from said hammer assemblies (430),

said muting system (750) including

an auxiliary toes (753) respectively provided on said jacks (424) closer to turning axes of said jacks (424) than said toes (424a), and

auxiliary regulating button mechanisms (752) changed between said enabled position (ENB) and said disabled position (DSA), said toes (424a) being brought into contact with said regulating button mechanisms (428) without a contact between said auxiliary toes (753) and said auxiliary regulating mechanisms (752) in said disabled position (DSA), said auxiliary toes (753) being brought into contact with said auxiliary regulating button mechanisms (752) in said enabled position (ENB) so that said jacks (424) turn around said turning axes faster.

10. A keyboard musical instrument having at least an acoustic sound mode for generating acoustic sounds and an electronic sound mode for generating electronic sounds, comprising:

an acoustic piano (100; 400)

an electronic sound generating system (200; 500) for generating said electronic sounds having the notes corresponding to the keys depressed by said player in said electronic sound mode; and

a silent system (300; 600) including a hammer stopper (310; 650) and a first actuator means (310d; 653b/653c/653d/653e) responsive to an instruction of said player so as to change said hammer stopper (310; 650) between said free position (FP) and said blocking position (BP),

characterized in that

said hammer stopper further includes

a first position controller having a first non-contact sensor (310i; 654c) operative to detect said interrupter (310a/310b/310c; 651/652d) upon an entry into said free position (FP) and a second non-contact sensor (310h; 654b) for detecting said interrupter (310a/310b/310c; 651/652d) upon an entry into said blocking position (BP).

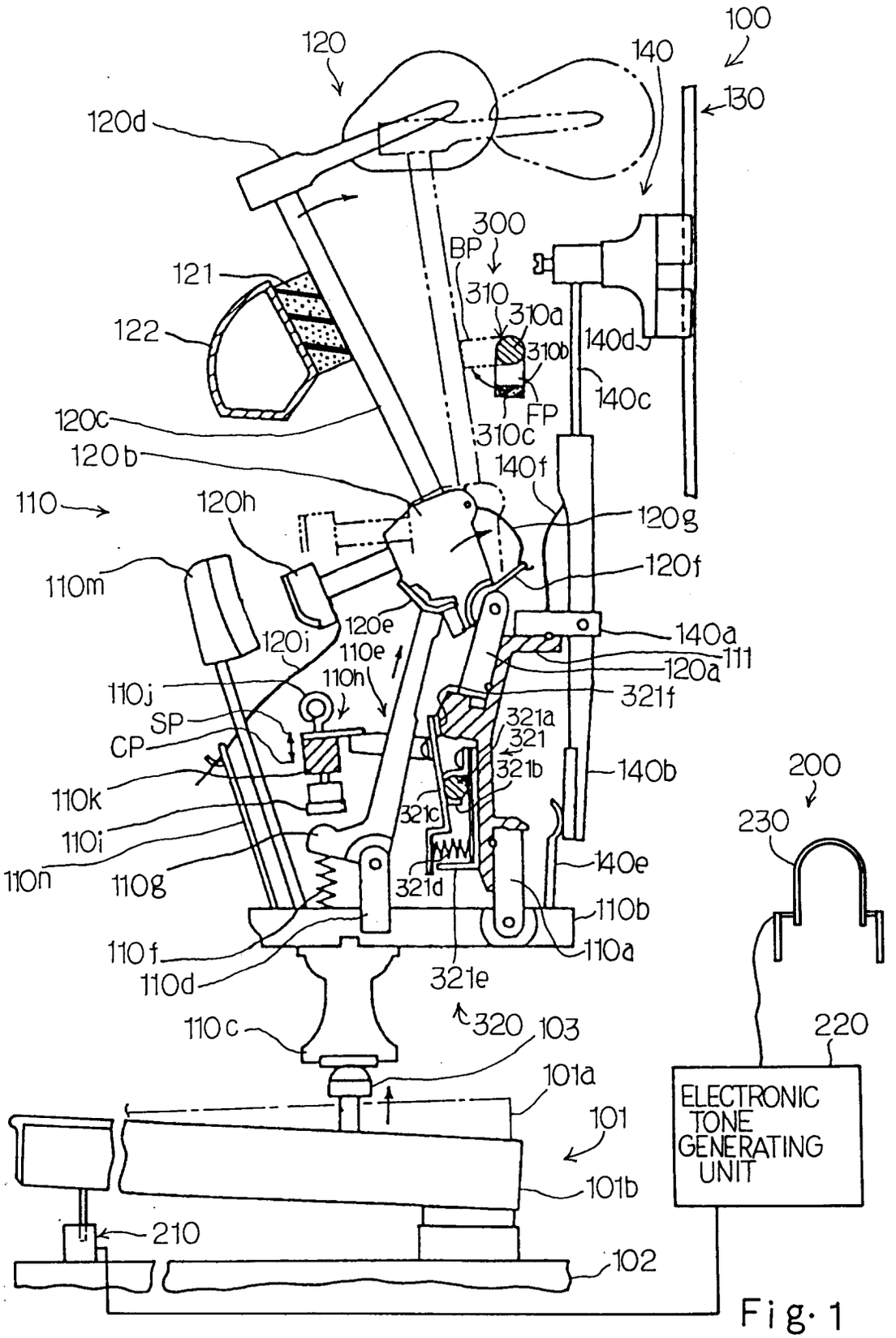
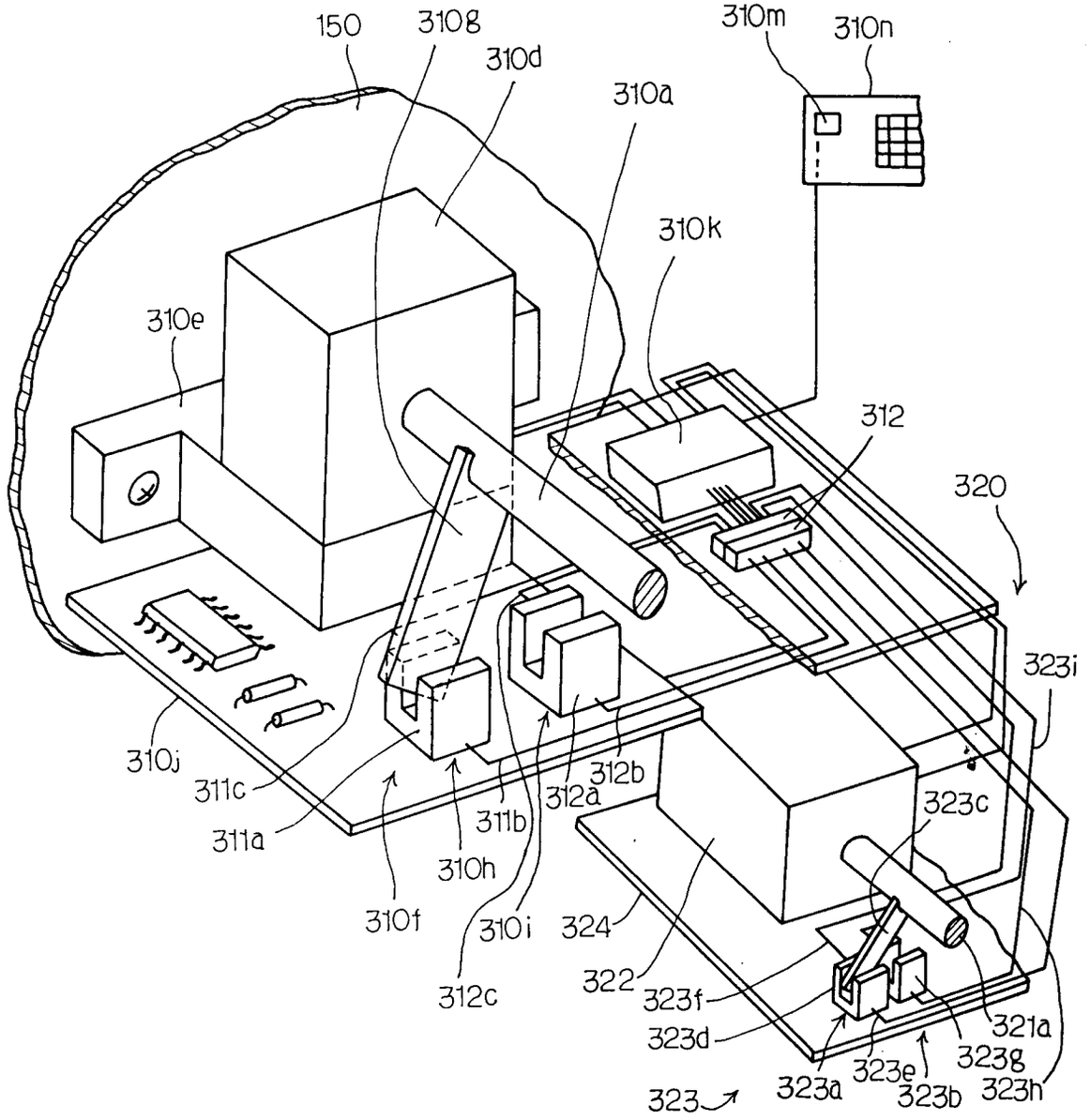

100
120
140
130
120d
300
BP
310
310a
310b
FP
310c
140d
140c
121
122
120c
120b
140f
110
120h
120g
110m
120f
120e
120i
110e
110h
140a
111
120a
110j
321f
SP
CP
321a
321
321b
140b
110k
321c
110i
110n
110g
321d
140e
110b
110f
110a
110d
321e
110c
320
103
101a
101
101b
210
102
200
230
220
ELECTRONIC TONE GENERATING UNIT

Fig. 1


150
310g
310d
310a
310m
310n
310k
310e
312
320
323i
310j
311c
311a
310h
311b
312a
312b
323c
310f
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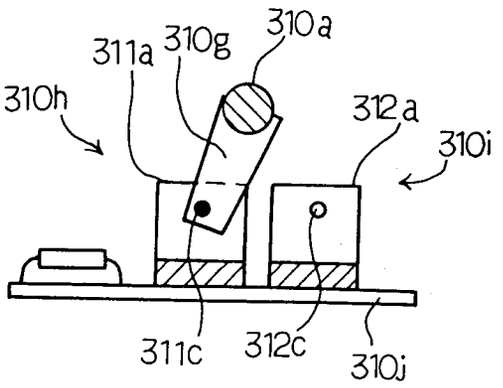
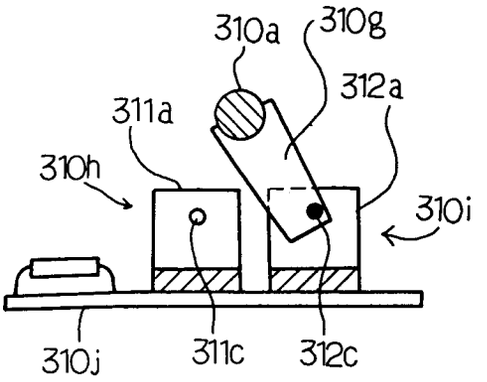
312c
323f
323d
321a
323g
323e
323a
323b
323h
323

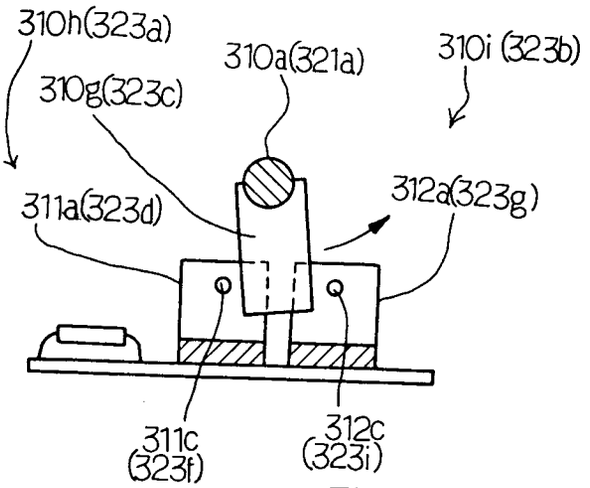
Fig. 2



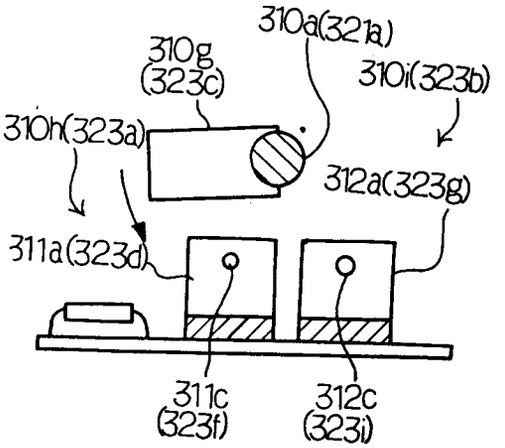
Fig·3A



Fig·3B



Fig·4A



Fig·4B

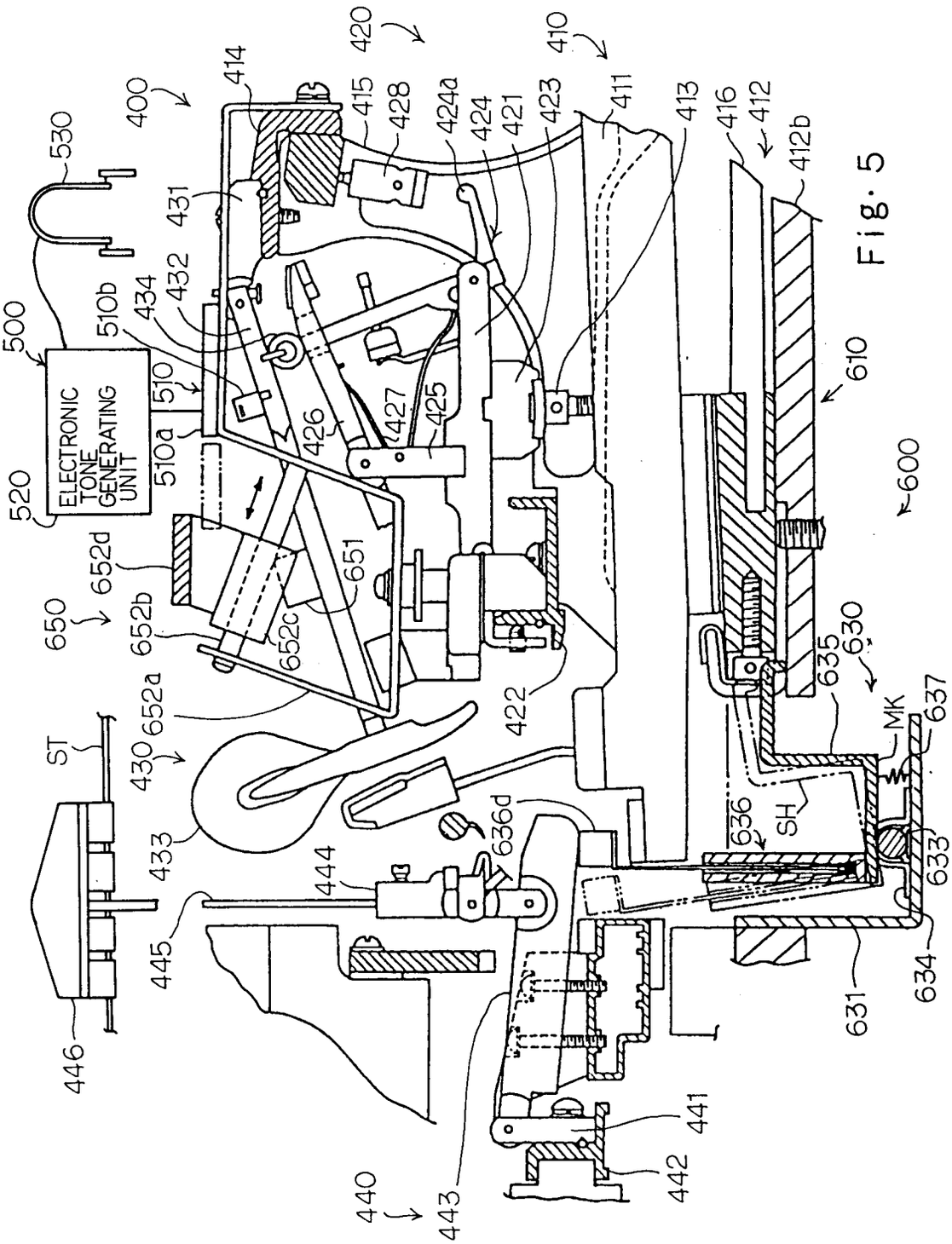
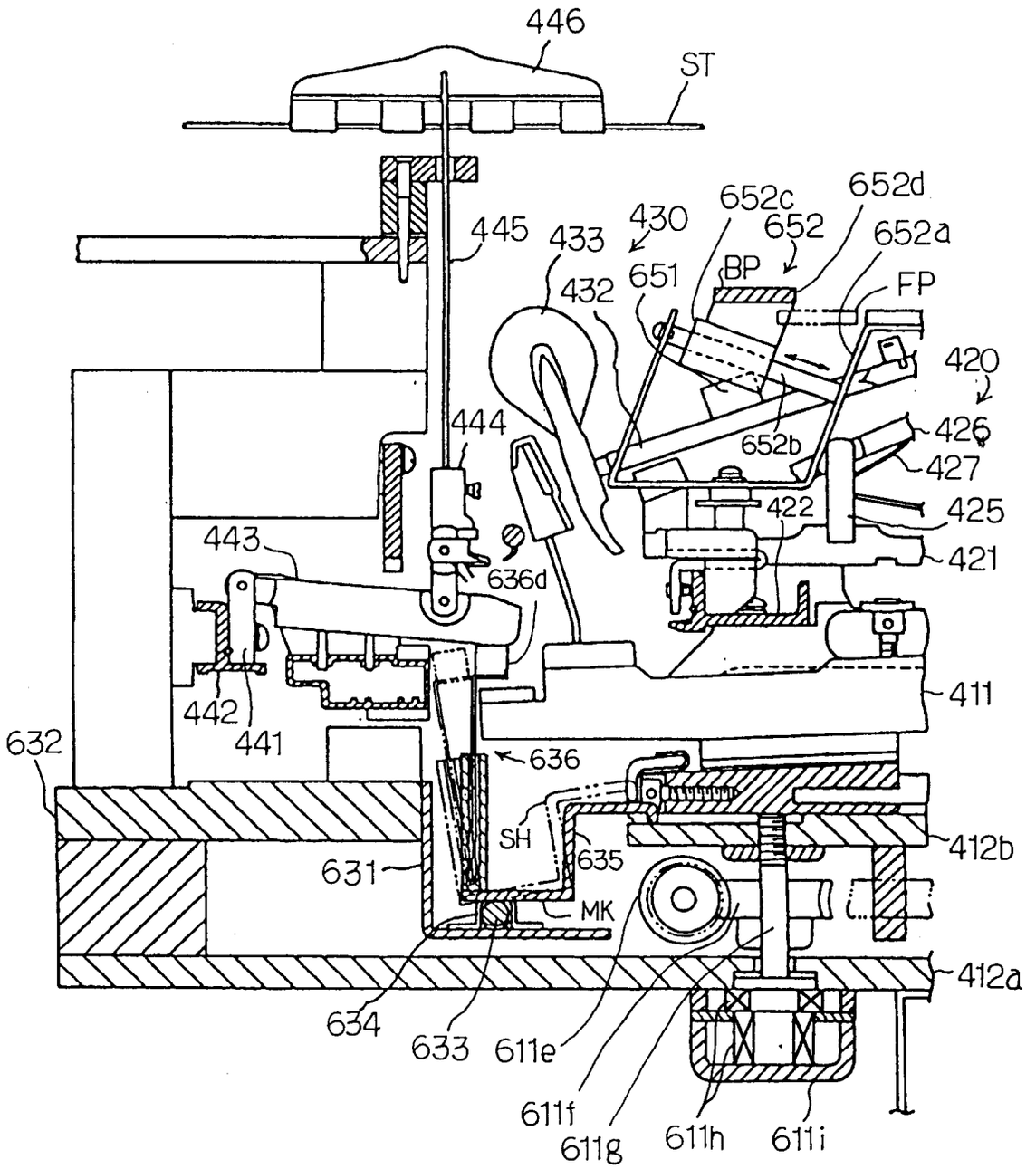

ELECTRONIC TONE GENERATING UNIT
500
520
530
400
414
420
415
428
424a
424
421
423
410
411
413
416
412
412b
431
432
434
510b
510
510a
426
427
425
610
600
650
652d
652b
652c
651
652a
422
630
635
637
MK
ST
430
433
636d
636
SH
633
444
445
446
634
631
440
443
441
442

Fig. 5


446
ST
445
433
430
652c
652d
652
652a
651
BP
FP
432
420
444
426
652b
427
422
425
443
421
636d
411
442
441
632
636
SH
635
412b
631
MK
412a
634
633
611e
611f
611g
611h
611i

Fig·6

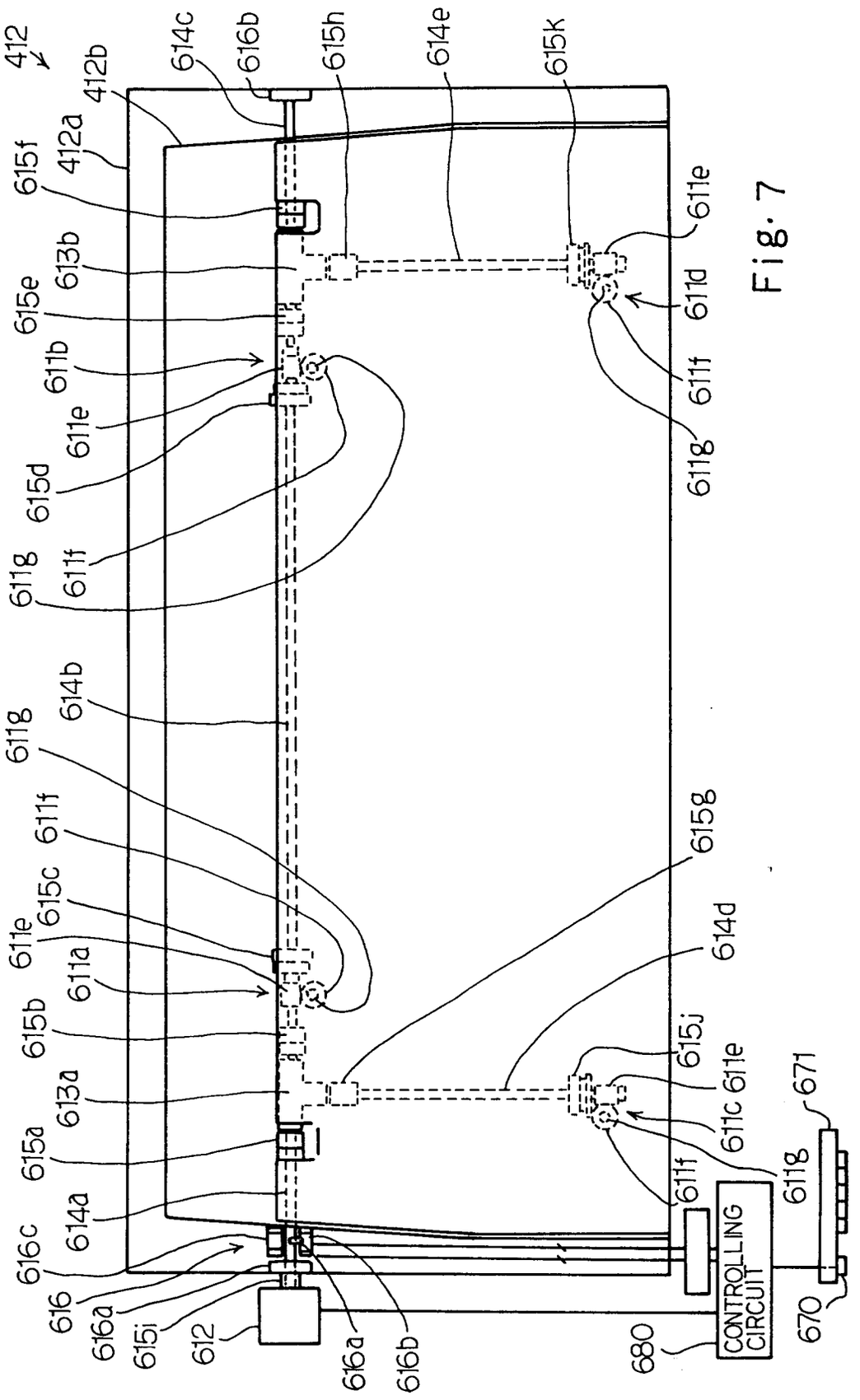

412
412b
412a
614c
616b
615h
614e
615k
615f
611e
613b
611d
615e
611f
611b
611g
611e
615d
611f
611g
614b
611g
611f
615g
615c
611e
614d
611a
615b
615j
613a
611e
611c
615a
671
611f
611g
614a
616c
CONTROLLING CIRCUIT
616
616a
615i
612
616a
616b
680
670

Fig. 7

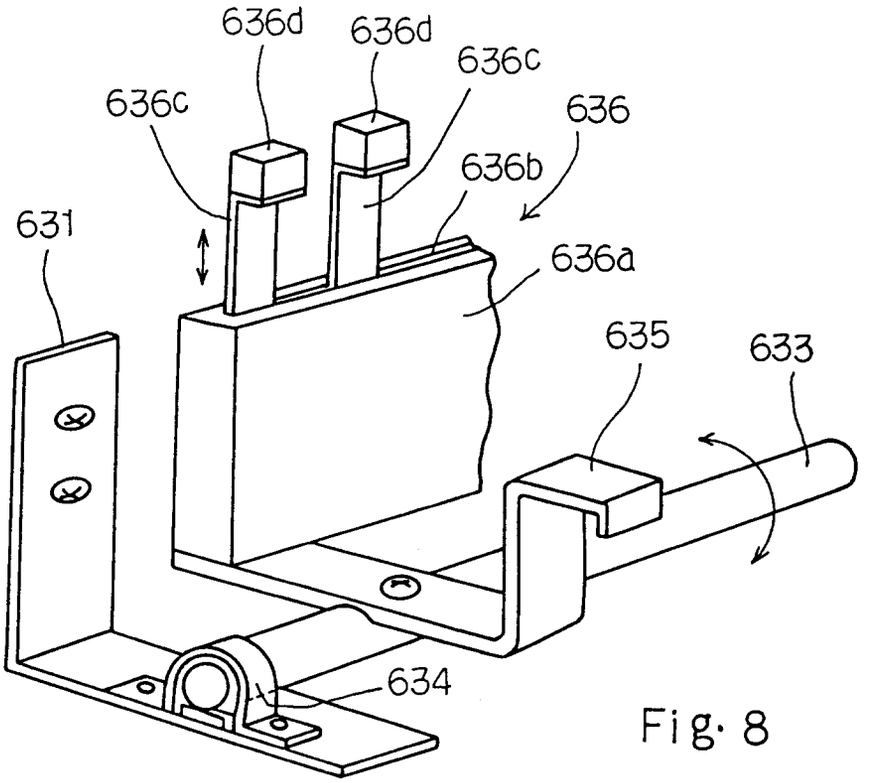

636d
636d
636c
636c
636
636b
631
636a
635
633
634

Fig. 8

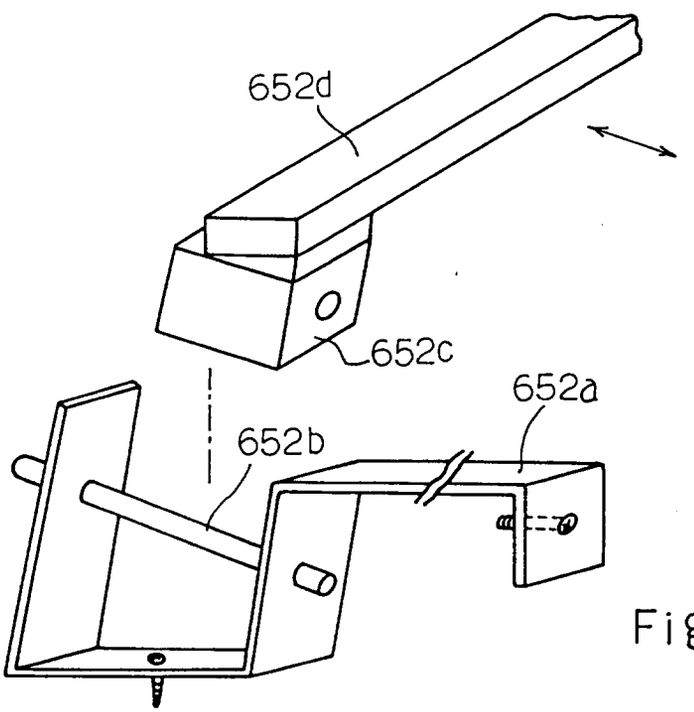

652d
652c
652a
652b

Fig. 9

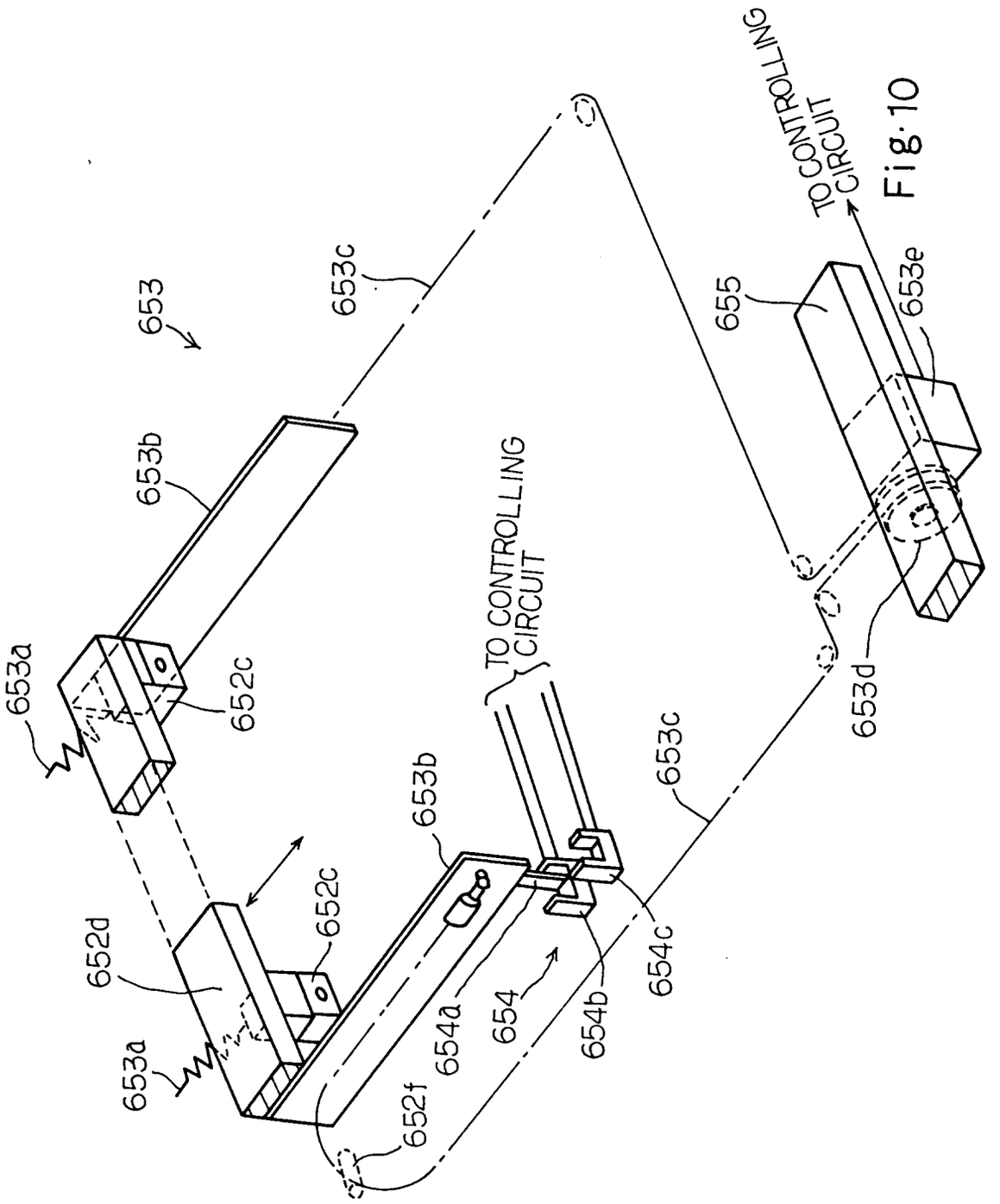

653
653c
653b
653a
652c
652d
652f
654
654a
654b
654c
655
653e
653d
TO CONTROLLING CIRCUIT
TO CONTROLLING CIRCUIT

Fig.10

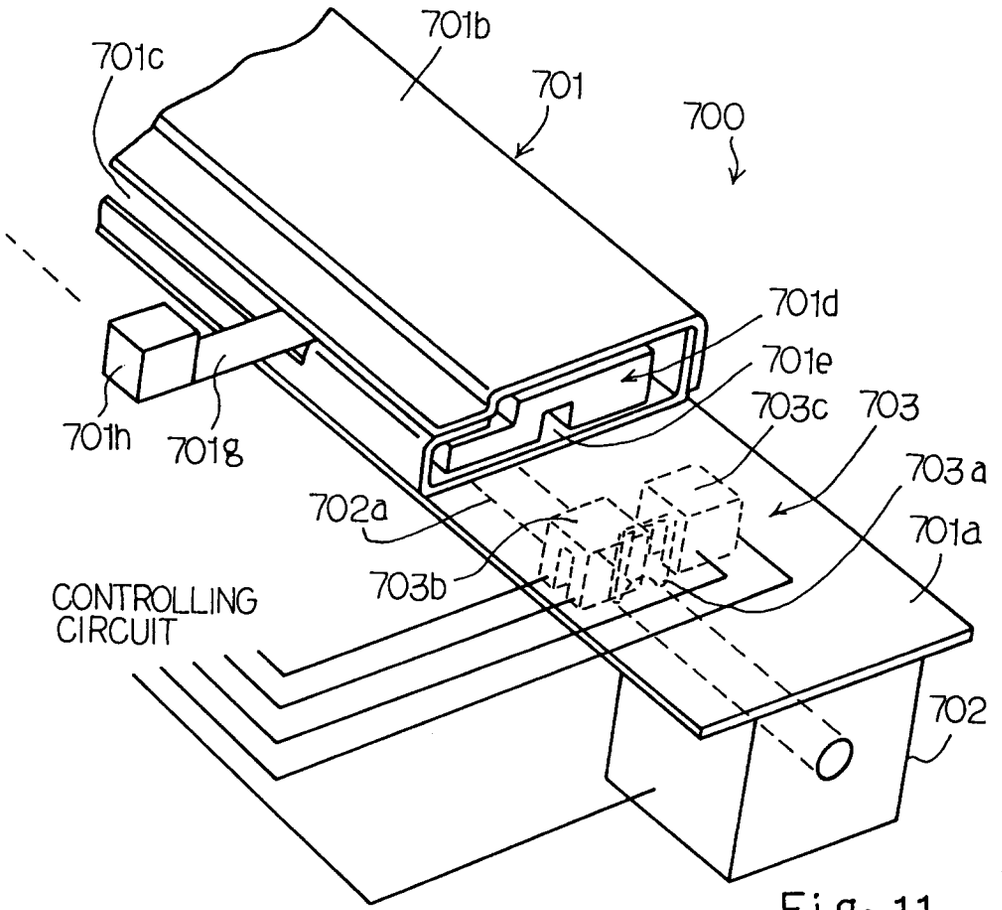

701b
701c
701
700
701d
701e
703c
703
703a
701h
701g
702a
701a
703b
CONTROLLING CIRCUIT
702

Fig. 11

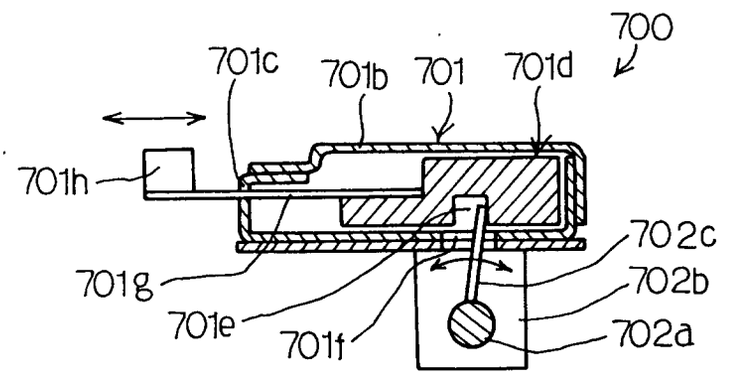

700
701c
701b
701
701d
701h
702c
701g
702b
701e
701f
702a

Fig. 12

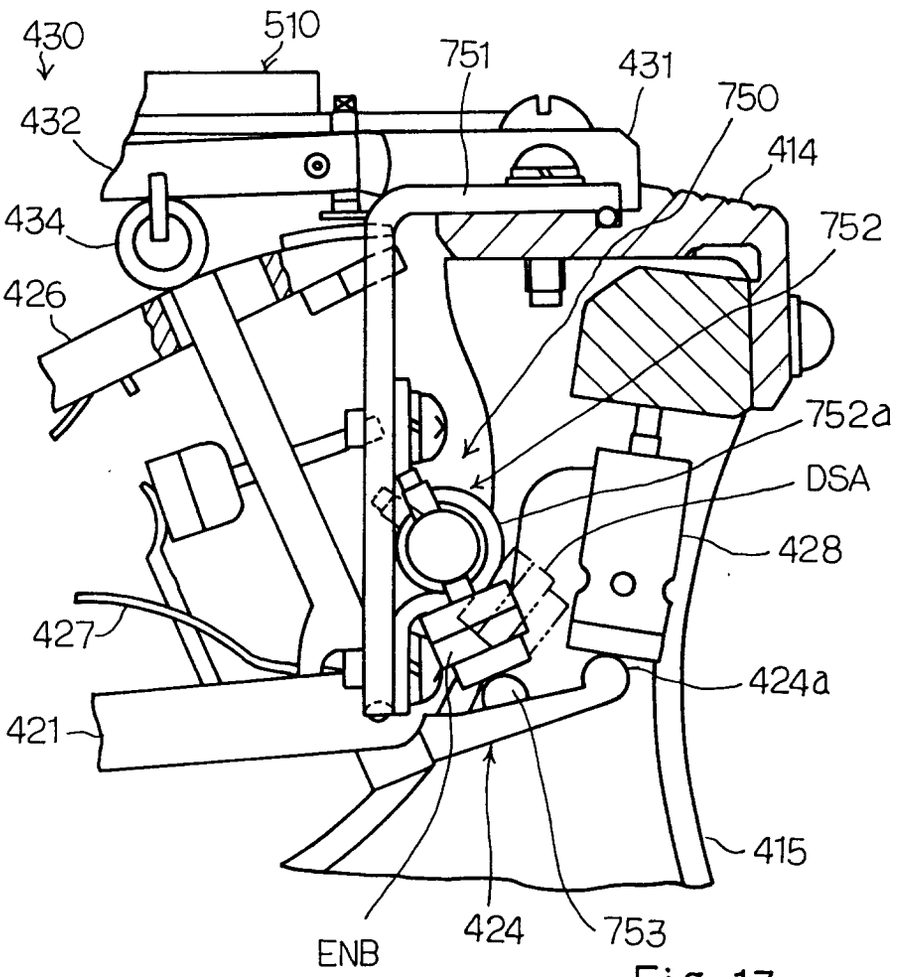

430
510
751
431
750
432
414
434
752
426
752a
DSA
428
427
424a
421
415
ENB
424
753

Fig. 13

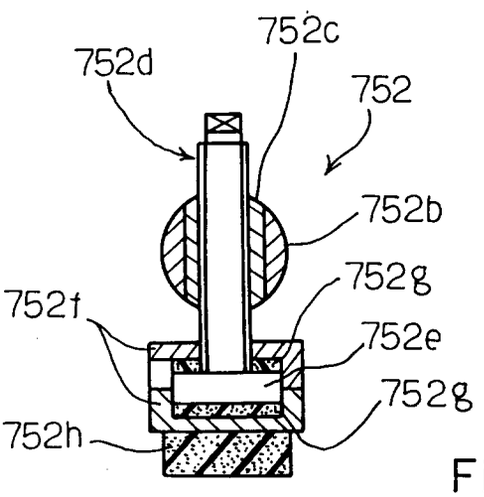
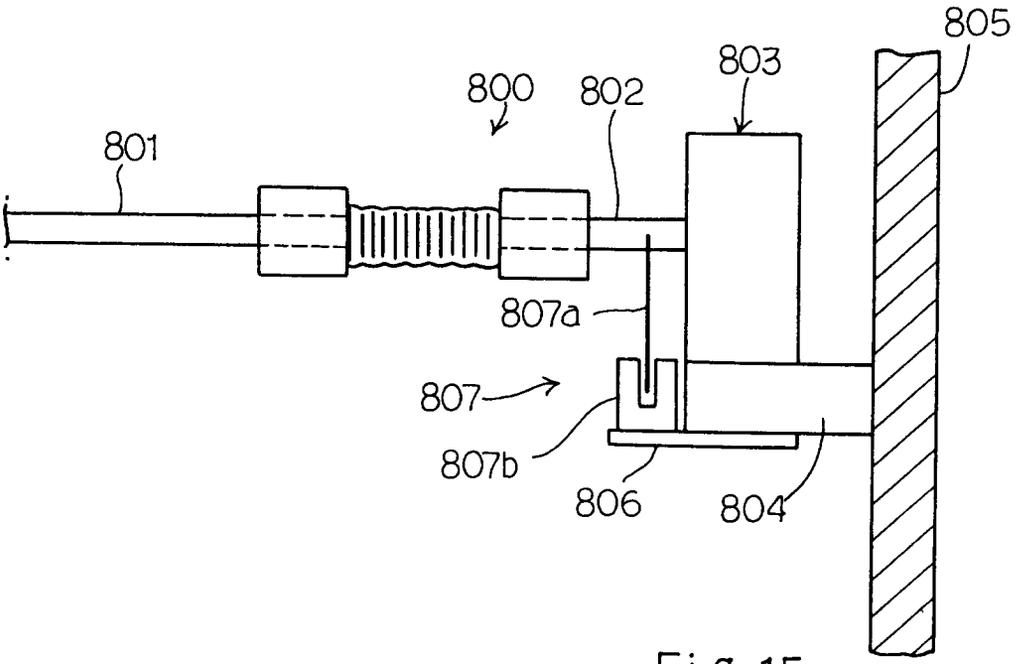
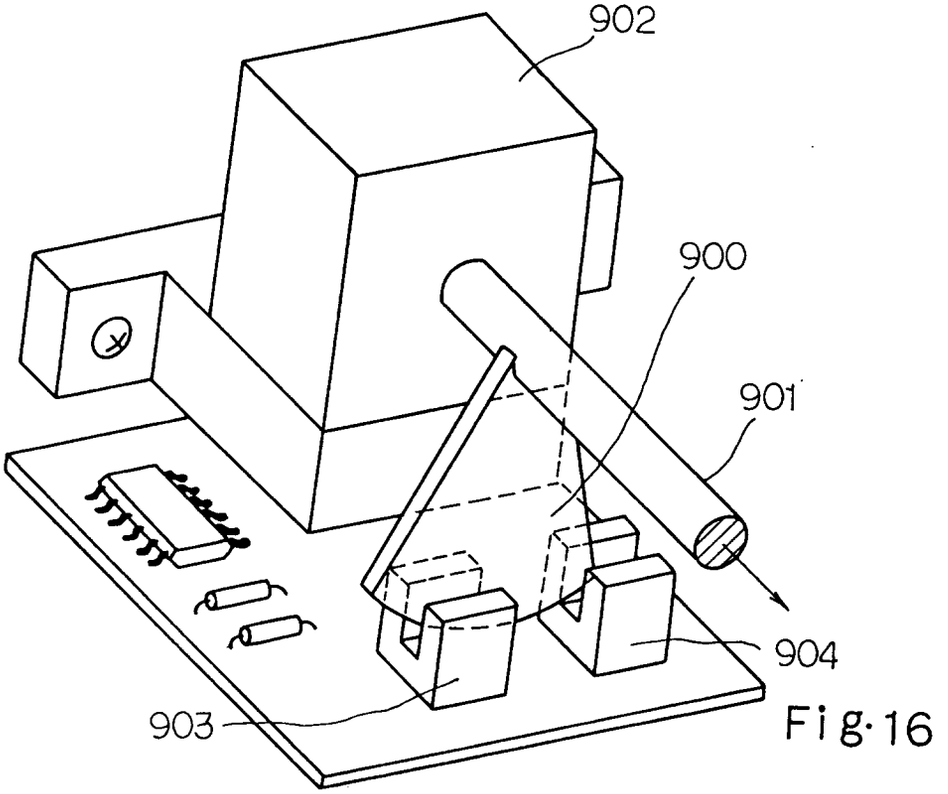

752c
752d
752
752b
752g
752f
752e
752g
752h

Fig. 14



Fig·15



Fig·16

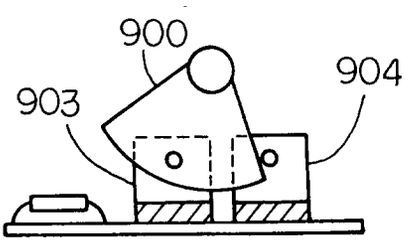


Fig. 17A

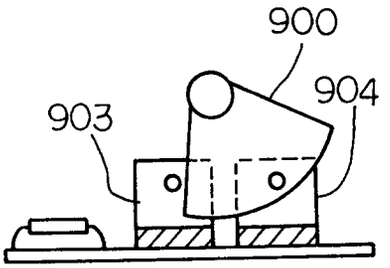


Fig. 17B

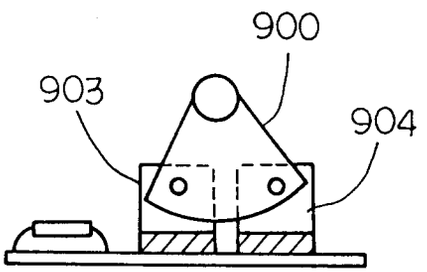


Fig. 17C

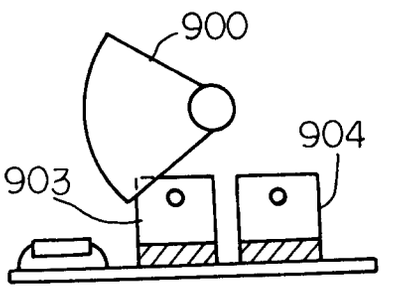


Fig. 17D

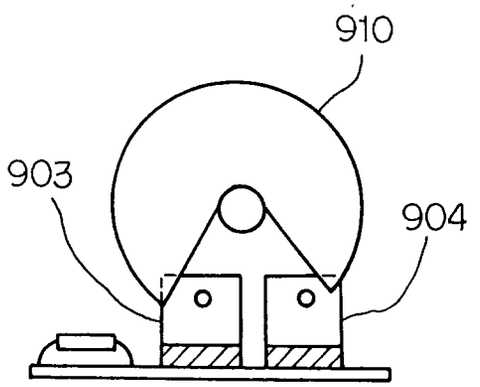


Fig. 18